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Residual Ranges

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A number of parameters that are generally used for the analysis of the heavy ion tracks in CR-39 Nuclear Track Detector have been computed. The parameters are: Residual Range(R), Velocity ($\beta = V/c$), Kinetic Energy per Nucleon (e/nucleon), Effective Charge (z_{eff}) and Energy Loss of

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20. heavy ions (dE/dx). The computation has been performed for isotopes of interest in cosmic ray work, with charges in the region $2 \leq z \leq 30$ and for residual range, $R \leq 30$ cm.

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Introduction:

A knowledge of accurate range-energy relations for charged particles is an essential requirement in the use of a nuclear track detector. This report presents computed track parameters that are normally used for the analysis of the heavy ion tracks in CR-39 Nuclear Track Detector. Computation has been performed for tracks of isotopes in the charge region $2 \leq z \leq 30$.

In any Nuclear Track Detector, the residual range of a stopping particle is a very easily measured quantity. We have therefore used the residual range, as the first entry in the track parameter table. (Printout Table I). The corresponding velocity is given in the second column. The velocity provides a link with the rest of the parameters. All the entries in a row are interdependent and the table will give the value of these parameters if any one is known. The calculations are based on theoretical and empirical relations which can be found in earlier works[1-3].

Appendix I gives a brief description of CR-39 nuclear track detector and a number of constants relating to composition of the detector. In Appendix II (Printout Table I) are listed a few quantities that are generally used in calculations on relativistic ions.

Description of Formulae:

i) Residual Range:

The residual range R, of a heavy ion with charge z and mass M for a certain velocity, β, can be determined by the general expression given by Heckman et al[1]

$$R = \frac{M}{z^2} \left[\lambda(\beta) + B_z(\beta) \right] \qquad \ldots \qquad (1)$$

Where $\lambda(\beta)$ is the range of the ideal proton as a function of its velocity. The function $B_z(\beta)$ corrects for the extension in range of an ion owing to charge-pickup at low velocities. In practice the quantity $B_z(\beta)$ is obtained by scaling the corresponding experimental expression for emulsion to other materials.

ii) Kinetic Energy:

The kinetic energy per nucleon, E, for an ion of mass M and mass number Λ with a velocity β is given by

$$E = M m_p c^2 (\gamma - 1) \qquad \ldots \qquad (2)$$

where

$$\gamma = (1 - \beta^2)^{-\frac{1}{2}}$$

$$M = \frac{\Lambda}{1.008}$$

and m_p is rest mass of proton.

iii) Effective Charge:

The effective charge, z_{eff}, of an ion of atomic number z and with a velocity β can be expressed as

$$z_{eff} = z \left[1 - \exp(-130\beta z^{-2/3}) \right] \qquad \ldots \qquad (3)$$

iv) Energy Loss:

The rate of loss of energy for an ion with effective charge, z_{eff},

and velocity β is given by

$$dE/dx = \frac{2\pi \, n z^2_{eff} \, r^2_o \, m_o c^2}{\beta^2} \left[\ell n \, \frac{2 m_o c^2 \beta^2 \gamma^2 W^2_{max}}{I^2_{adj}} - 2\beta^2 - 2c/Z - \delta^2 \right] \quad \ldots (4)$$

where

n = the electron density in the stopping medium

m = the mass of an electron

r_o = $e^2/m_o c^2$, the classical electron radius

I_{adj} = the mean ionization potential of the atoms of the stopping medium

W_{max} = the maximum energy transfer from the incident particle to the atomic electron

c/Z = tight binding shell correction, and

δ = a correction term which accounts for the density effect at high velocities.

Appendix 1

CR-39 allyl diglycol carbonate is a colorless, liquid organic ester of low volatility and low viscosity[4]. It is miscible or compatible with a wide variety of solvents, plasticizers and resinuous or plastic materials. If heated with a polymerization catalyst such as benzoyl peroxide, the liquid gradually thickens to form a soft gel. With further heating, the gel hardens into a insoluble, clear colorless solid. Because of its unique combination of properties, such as high abrasion resistance, clarity and low color, combined with solvent and temperature resistance, polymeric CR-39 is useful in the form of clear sheets. So far the main uses of CR-39 plastics have been as eye wear lenses and instrument gauge covers. Examples of other uses include glazing, safety shields and guards, navigation equipment, laboratory equipment and photographic filters.

In recent years solid state nuclear track detectors have found widespread application[5]. The production of tracks by energetic ions in insulating materials is a widely used technique for detection and identification of ions. Their utilization showed to be very successful in the study of very heavy primary cosmic rays, recording of fission fragments and innumerable applications in the studies on radiation dosimetry. Also, there have been some investigations exploring the possibility of their application to detect protons.

The use of plastic sheet cast from CR-39 monomer with excellent etching properties, high sensitivity and high uniformity as a nuclear track detector was reported recently[6]. This material was found to have

a lower detection threshold ($z/\beta = 9$) than cellulose nitrate ($z/\beta = 20$) and a smaller variation of response ($\sim 1\%$) to particles of a given ionization rate than lexan polycarbonate (~ 3 to 8%). Commercially available CR-39 is capable of recording protons of 1 MeV and below as well as 6 MeV alpha particles. Recently, it has been shown that CR-39 plastic can be used as a detector to observe monoenergetic protons with energies up to 4.3 MeV[7].

<u>Constants for CR-39 Detector</u>:

Density	....	....	1.32 gm/cm^3
Effective A/Z	....	....	1.877

PRINTOUT TABLE I

Velocity (β), Energy (E, MeV/amu), Effective Charge (z_{eff}), Rate of Loss
of Energy (dE/dx, MeV/cm) as a function of Heavy Ion Range (R, cm)

RANGE -ENERGY DATA FOR CR-39

ION IS 1 P 1						ION IS 2 HE 3				
RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM		RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0506	1.2	.999	300.008		.0025	.0545	1.4	1.977	1085.157
.0050	.0625	1.8	1.000	224.375		.0050	.0677	2.1	1.992	799.705
.0075	.0707	2.3	1.000	187.875		.0075	.0767	2.7	1.996	664.619
.0100	.0770	2.8	1.000	165.066		.0100	.0835	3.3	1.998	581.947
.0200	.0942	4.2	1.000	119.956		.0200	.1021	4.9	2.000	420.131
.0300	.1057	5.2	1.000	99.066		.0300	.1144	6.2	2.000	347.629
.0400	.1145	6.2	1.000	86.768		.0400	.1239	7.2	2.000	305.860
.0500	.1218	7.0	1.000	78.592		.0500	.1317	8.2	2.000	276.970
.0600	.1280	7.7	1.000	72.485		.0600	.1383	9.0	2.000	255.431
.0700	.1335	8.4	1.000	67.695		.0700	.1442	9.8	2.000	239.326
.0800	.1384	9.0	1.000	63.806		.0800	.1497	10.6	2.000	224.074
.0900	.1428	9.6	1.000	60.565		.0900	.1546	11.3	2.000	212.215
.1000	.1471	10.2	1.000	57.675		.1000	.1592	12.0	2.000	202.143
.1500	.1644	12.8	1.000	47.842		.1500	.1778	15.1	2.000	167.683
.2000	.1778	15.1	1.000	41.907		.2000	.1922	17.7	2.000	146.912
.3000	.1984	18.9	1.000	34.789		.3000	.2142	22.1	2.000	122.827
.4000	.2142	22.1	1.000	30.502		.4000	.2312	25.9	2.000	107.050
.5000	.2273	25.0	1.000	27.555		.5000	.2452	29.3	2.000	96.761
.6000	.2385	27.7	1.000	25.368		.6000	.2572	32.4	2.000	89.128
.7000	.2484	30.1	1.000	23.661		.7000	.2677	35.3	2.000	83.170
.8000	.2572	32.4	1.000	22.280		.8000	.2772	38.0	2.000	78.351
.9000	.2652	34.6	1.000	21.133		.9000	.2857	40.5	2.000	74.348
1.0000	.2726	36.6	1.000	20.159		1.0000	.2936	42.9	2.000	70.952
1.5000	.3026	45.8	1.000	16.837		1.5000	.3257	53.7	2.000	59.365
2.0000	.3257	53.7	1.000	14.841		2.0000	.3502	63.0	2.000	52.403
2.5000	.3446	60.8	1.000	13.470		2.5000	.3703	71.3	2.000	47.623
3.0000	.3607	67.2	1.000	12.454		3.0000	.3875	78.9	2.000	44.079
3.5000	.3749	73.2	1.000	11.661		3.5000	.4025	86.0	2.000	41.313
4.0000	.3875	78.9	1.000	11.019		4.0000	.4158	92.7	2.000	39.077
5.0000	.4093	89.4	1.000	10.035		5.0000	.4389	105.1	2.000	35.644
6.0000	.4279	99.1	1.000	9.305		6.0000	.4584	116.6	2.000	33.099
7.0000	.4440	108.1	1.000	8.735		7.0000	.4754	127.3	2.000	31.114
8.0000	.4584	116.6	1.000	8.275		8.0000	.4905	137.4	2.000	29.509
9.0000	.4714	124.6	1.000	7.892		9.0000	.5040	147.0	2.000	28.175
10.0000	.4832	132.4	1.000	7.568		10.0000	.5163	156.2	2.000	27.045
15.0000	.5303	167.2	1.000	6.462		15.0000	.5653	197.7	2.000	23.194
20.0000	.5653	197.7	1.000	5.798		20.0000	.6014	234.3	2.000	20.885
30.0000	.6164	251.3	1.000	5.007		30.0000	.6534	298.9	2.000	18.139

9

ION IS	2 HE	4			ION IS	3 LI	6		
RANGE	BETA	ENERGY	ZEFF	DE/DX	RANGE	BETA	ENERGY	ZEFF	DE/DX
(CM)	(V/C)	(MEV/AMU)		MEV/CM	(CM)	(V/C)	(MEV/AMU)		MEV/CM
.0025	.0497	1.1	1.966	1229.573	.0025	.0550	1.4	2.903	2412.325
.0050	.0620	1.8	1.988	908.803	.0050	.0693	2.2	2.960	1741.232
.0075	.0702	2.3	1.994	758.046	.0075	.0787	2.9	2.978	1436.249
.0100	.0767	2.7	1.996	664.619	.0100	.0859	3.5	2.986	1252.628
.0200	.0940	4.1	1.999	481.449	.0200	.1052	5.2	2.996	898.425
.0300	.1056	5.2	2.000	397.173	.0300	.1180	6.5	2.998	744.698
.0400	.1144	6.2	2.000	347.628	.0400	.1277	7.7	2.999	654.683
.0500	.1217	7.0	2.000	314.771	.0500	.1358	8.7	2.999	592.539
.0600	.1279	7.7	2.000	290.250	.0600	.1426	9.6	3.000	546.378
.0700	.1334	8.4	2.000	271.030	.0700	.1489	10.5	3.000	508.593
.0800	.1383	9.0	2.000	255.431	.0800	.1545	11.3	3.000	478.099
.0900	.1427	9.6	2.000	242.436	.0900	.1596	12.1	3.000	452.737
.1000	.1470	10.2	2.000	230.853	.1000	.1643	12.8	3.000	431.208
.1500	.1644	12.8	2.000	191.452	.1500	.1835	16.1	3.000	357.630
.2000	.1778	15.1	2.000	167.683	.2000	.1983	18.9	3.000	313.329
.3000	.1984	18.9	2.000	139.187	.3000	.2210	23.6	3.000	260.295
.4000	.2142	22.1	2.000	122.027	.4000	.2384	27.7	3.000	228.396
.5000	.2273	25.0	2.000	110.235	.5000	.2529	31.3	3.000	206.489
.6000	.2385	27.7	2.000	101.484	.6000	.2652	34.6	3.000	190.239
.7000	.2483	30.1	2.000	94.653	.7000	.2760	37.6	3.000	177.559
.8000	.2572	32.4	2.000	89.128	.8000	.2857	40.5	3.000	167.303
.9000	.2652	34.6	2.000	84.537	.9000	.2945	43.2	3.000	158.784
1.0000	.2726	36.6	2.000	80.642	1.0000	.3026	45.8	3.000	151.558
1.5000	.3026	45.8	2.000	67.352	1.5000	.3355	57.3	3.000	126.905
2.0000	.3257	53.7	2.000	59.365	2.0000	.3607	67.2	3.000	112.092
2.5000	.3446	60.8	2.000	53.882	2.5000	.3813	76.1	3.000	101.924
3.0000	.3607	67.2	2.000	49.816	3.0000	.3989	84.3	3.000	94.385
3.5000	.3749	73.2	2.000	46.644	3.5000	.4142	91.9	3.000	88.503
4.0000	.3875	78.9	2.000	44.079	4.0000	.4279	99.1	3.000	83.746
5.0000	.4093	89.4	2.000	40.140	5.0000	.4514	112.4	3.000	76.445
6.0000	.4279	99.1	2.000	37.220	6.0000	.4714	124.6	3.000	71.031
7.0000	.4440	108.1	2.000	34.941	7.0000	.4887	136.1	3.000	66.809
8.0000	.4584	116.6	2.000	33.099	8.0000	.5040	147.0	3.000	63.396
9.0000	.4714	124.6	2.000	31.569	9.0000	.5178	157.3	3.000	60.561
10.0000	.4832	132.4	2.000	30.272	10.0000	.5303	167.2	3.000	58.158
15.0000	.5303	167.2	2.000	25.848	15.0000	.5800	211.9	3.000	49.971
20.0000	.5653	197.7	2.000	23.194	20.0000	.6164	251.3	3.000	45.068
30.0000	.6164	251.3	2.000	20.030	30.0000	.6686	321.1	3.000	39.239

ION IS 3 LI 7

RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0520	1.3	2.884	2592.289
.0050	.0659	2.0	2.951	1873.850
.0075	.0750	2.6	2.972	1545.303
.0100	.0820	3.1	2.982	1347.959
.0200	.1007	4.8	2.994	967.777
.0300	.1130	6.0	2.997	797.995
.0400	.1224	7.1	2.999	701.439
.0500	.1302	8.0	2.999	634.801
.0600	.1368	8.8	2.999	585.193
.0700	.1426	9.6	3.000	546.378
.0800	.1480	10.4	3.000	513.474
.0900	.1529	11.1	3.000	486.215
.1000	.1575	11.8	3.000	463.073
.1500	.1760	14.8	3.000	383.962
.2000	.1902	17.3	3.000	336.318
.3000	.2121	21.7	3.000	279.267
.4000	.2289	25.4	3.000	244.946
.5000	.2428	28.7	3.000	221.372
.6000	.2547	31.8	3.000	203.885
.7000	.2652	34.6	3.000	190.239
.8000	.2745	37.2	3.000	179.201
.9000	.2830	39.7	3.000	170.032
1.0000	.2908	42.1	3.000	162.255
1.5000	.3227	52.6	3.000	135.720
2.0000	.3470	61.7	3.000	119.776
2.5000	.3670	69.8	3.000	108.832
3.0000	.3840	77.3	3.000	100.716
3.5000	.3989	84.3	3.000	94.385
4.0000	.4121	90.8	3.000	89.265
5.0000	.4350	103.0	3.000	81.405
6.0000	.4545	114.2	3.000	75.577
7.0000	.4714	124.6	3.000	71.031
8.0000	.4863	134.5	3.000	67.356
9.0000	.4998	143.9	3.000	64.304
10.0000	.5121	152.9	3.000	61.716
15.0000	.5608	193.5	3.000	52.896
20.0000	.5968	229.3	3.000	47.609
30.0000	.6487	292.4	3.000	41.317

ION IS 4 BE 7

RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0613	1.8	3.831	3653.686
.0050	.0778	2.8	3.928	2597.128
.0075	.0885	3.7	3.958	2124.253
.0100	.0966	4.4	3.973	1843.408
.0200	.1181	6.6	3.991	1322.149
.0300	.1322	8.2	3.996	1100.649
.0400	.1430	9.7	3.997	967.303
.0500	.1522	11.0	3.998	871.426
.0600	.1601	12.2	3.999	800.597
.0700	.1671	13.3	3.999	745.320
.0800	.1733	14.3	3.999	700.605
.0900	.1789	15.3	4.000	663.451
.1000	.1842	16.2	4.000	631.934
.1500	.2054	20.3	4.000	524.367
.2000	.2218	23.8	4.000	459.704
.3000	.2469	29.8	4.000	382.383
.4000	.2662	34.9	4.000	335.918
.5000	.2821	39.4	4.000	304.025
.6000	.2957	43.6	4.000	280.374
.7000	.3076	47.5	4.000	261.923
.8000	.3183	51.1	4.000	247.002
.9000	.3230	54.5	4.000	234.608
1.0000	.3369	57.8	4.000	224.097
1.5000	.3729	72.4	4.000	188.241
2.0000	.4004	85.0	4.000	166.700
2.5000	.4228	96.4	4.000	151.916
3.0000	.4418	106.8	4.000	140.954
3.5000	.4584	116.6	4.000	132.403
4.0000	.4731	125.8	4.000	125.489
5.0000	.4984	142.9	4.000	114.878
6.0000	.5197	158.7	4.000	107.013
7.0000	.5381	173.5	4.000	100.882
8.0000	.5543	187.6	4.000	95.927
9.0000	.5688	201.0	4.000	91.814
10.0000	.5819	213.9	4.000	88.329
15.0000	.6335	272.3	4.000	76.475
20.0000	.6707	324.2	4.000	69.397
30.0000	.7230	416.8	4.000	61.028

ION IS	4 BE	9			ION IS	4 BE	10		
RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM	RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0558	1.5	3.775	4039.724	.0025	.0536	1.3	3.748	4203.918
.0050	.0716	2.4	3.900	2943.804	.0050	.0690	2.2	3.886	3102.088
.0075	.0818	3.1	3.941	2404.701	.0075	.0791	2.9	3.932	2534.629
.0100	.0895	3.8	3.960	2086.457	.0100	.0866	3.5	3.954	2195.341
.0200	.1099	5.7	3.986	1482.845	.0200	.1066	5.3	3.984	1561.921
.0300	.1233	7.2	3.993	1232.901	.0300	.1197	6.7	3.992	1293.196
.0400	.1335	8.4	3.996	1082.777	.0400	.1297	7.9	3.995	1135.409
.0500	.1419	9.5	3.997	979.577	.0500	.1379	9.0	3.997	1026.954
.0600	.1493	10.6	3.998	899.871	.0600	.1450	9.9	3.998	945.154
.0700	.1559	11.5	3.999	837.579	.0700	.1514	10.9	3.998	879.659
.0800	.1617	12.4	3.999	787.189	.0800	.1571	11.7	3.999	826.680
.0900	.1671	13.3	3.999	745.320	.0900	.1623	12.5	3.999	782.661
.1000	.1720	14.1	3.999	709.804	.1000	.1671	13.3	3.999	745.320
.1500	.1920	17.7	4.000	588.577	.1500	.1866	16.6	4.000	617.866
.2000	.2074	20.7	4.000	515.695	.2000	.2017	19.5	4.000	541.236
.3000	.2311	25.9	4.000	428.534	.3000	.2247	24.4	4.000	449.590
.4000	.2493	30.4	4.000	376.151	.4000	.2425	28.6	4.000	394.507
.5000	.2643	34.3	4.000	340.192	.5000	.2571	32.4	4.000	356.694
.6000	.2771	37.9	4.000	313.525	.6000	.2696	35.8	4.000	328.652
.7000	.2884	41.3	4.000	292.721	.7000	.2806	39.0	4.000	306.774
.8000	.2985	44.5	4.000	275.897	.8000	.2905	42.0	4.000	289.082
.9000	.3076	47.5	4.000	261.923	.9000	.2994	44.8	4.000	274.386
1.0000	.3160	50.3	4.000	250.071	1.0000	.3076	47.5	4.000	261.923
1.5000	.3502	63.0	4.000	209.641	1.5000	.3410	59.4	4.000	219.406
2.0000	.3763	73.9	4.000	185.352	2.0000	.3666	69.7	4.000	193.863
2.5000	.3977	83.7	4.000	168.681	2.5000	.3875	78.9	4.000	176.331
3.0000	.4158	92.7	4.000	156.320	3.0000	.4052	87.4	4.000	163.331
3.5000	.4316	101.1	4.000	146.677	3.5000	.4208	95.3	4.000	153.190
4.0000	.4457	109.0	4.000	138.879	4.0000	.4346	102.7	4.000	144.990
5.0000	.4700	123.8	4.000	126.911	5.0000	.4584	116.6	4.000	132.403
6.0000	.4905	137.3	4.000	118.038	6.0000	.4786	129.3	4.000	123.071
7.0000	.5083	150.1	4.000	111.119	7.0000	.4961	141.2	4.000	115.792
8.0000	.5240	162.1	4.000	105.526	8.0000	.5115	152.5	4.000	109.909
9.0000	.5381	173.5	4.000	100.882	9.0000	.5254	163.3	4.000	105.023
10.0000	.5509	184.5	4.000	96.946	10.0000	.5331	173.5	4.000	100.882
15.0000	.6014	234.3	4.000	83.542	15.0000	.5881	220.1	4.000	86.775
20.0000	.6382	278.3	4.000	75.523	20.0000	.6246	261.2	4.000	78.329
30.0000	.6907	356.4	4.000	66.007	30.0000	.6770	334.0	4.000	68.295

ION IS 5 B 11						ION IS 6 C 12				
RANGE	BETA	ENERGY	ZEFF	DE/DX		RANGE	BETA	ENERGY	ZEFF	DE/DX
(CM)	(V/C)	(MEV/AMU)		MEV/CM		(CM)	(V/C)	(MEV/AMU)		MEV/CM
.0025	.0586	1.6	4.630	5578.838		.0025	.0627	1.8	5.492	7052.545
.0050	.0757	2.7	4.828	4188.030		.0050	.0813	3.1	5.755	5264.838
.0075	.0869	3.5	4.895	3409.299		.0075	.0934	4.1	5.848	4353.495
.0100	.0953	4.3	4.928	2944.232		.0100	.1024	4.9	5.894	3751.410
.0200	.1172	6.5	4.973	2089.754		.0200	.1261	7.5	5.958	2671.870
.0300	.1315	8.2	4.986	1734.342		.0300	.1414	9.5	5.977	2215.305
.0400	.1424	9.6	4.991	1521.906		.0400	.1535	11.2	5.986	1932.633
.0500	.1516	10.9	4.994	1370.187		.0500	.1635	12.7	5.990	1739.369
.0600	.1596	12.1	4.996	1258.041		.0600	.1720	14.1	5.993	1596.619
.0700	.1665	13.2	4.997	1170.663		.0700	.1795	15.4	5.995	1485.546
.0800	.1728	14.2	4.998	1100.065		.0800	.1862	16.6	5.996	1395.891
.0900	.1785	15.2	4.998	1041.459		.0900	.1922	17.7	5.997	1321.525
.1000	.1837	16.1	4.999	991.780		.1000	.1978	18.8	5.998	1258.525
.1500	.2050	20.2	4.999	822.446		.1500	.2206	23.5	5.999	1044.037
.2000	.2214	23.7	5.000	720.797		.2000	.2382	27.6	5.999	915.450
.3000	.2465	29.6	5.000	599.366		.3000	.2650	34.5	6.000	761.981
.4000	.2657	34.7	5.000	526.445		.4000	.2855	40.5	6.000	669.884
.5000	.2816	39.3	5.000	476.411		.5000	.3025	45.8	6.000	606.714
.6000	.2952	43.4	5.000	439.317		.6000	.3169	50.6	6.000	559.892
.7000	.3071	47.3	5.000	410.383		.7000	.3296	55.1	6.000	523.375
.8000	.3178	50.9	5.000	386.987		.8000	.3410	59.4	6.000	493.852
.9000	.3275	54.3	5.000	367.556		.9000	.3512	63.4	6.000	469.333
1.0000	.3363	57.6	5.000	351.078		1.0000	.3606	67.2	6.000	448.541
1.5000	.3724	72.2	5.000	294.874		1.5000	.3988	84.2	6.000	377.634
2.0000	.3998	84.7	5.000	261.113		2.0000	.4278	99.0	6.000	335.046
2.5000	.4222	96.0	5.000	237.943		2.5000	.4514	112.4	6.000	305.824
3.0000	.4412	106.5	5.000	220.765		3.0000	.4713	124.6	6.000	284.159
3.5000	.4578	116.2	5.000	207.365		3.5000	.4887	136.1	6.000	267.263
4.0000	.4725	125.3	5.000	196.531		4.0000	.5040	146.9	6.000	253.604
5.0000	.4977	142.4	5.000	179.904		5.0000	.5303	167.2	6.000	232.648
6.0000	.5190	158.2	5.000	167.581		6.0000	.5524	185.9	6.000	217.122
7.0000	.5374	173.0	5.000	157.973		7.0000	.5714	203.4	6.000	205.023
8.0000	.5536	187.0	5.000	150.208		8.0000	.5881	220.1	6.000	195.250
9.0000	.5681	200.3	5.000	143.764		9.0000	.6029	236.0	6.000	187.143
10.0000	.5812	213.1	5.000	138.304		10.0000	.6164	251.3	6.000	180.277
15.0000	.6328	271.4	5.000	119.728		15.0000	.6686	321.1	6.000	156.959
20.0000	.6699	323.1	5.000	108.637		20.0000	.7059	383.4	6.000	143.084
30.0000	.7223	415.3	5.000	95.522		30.0000	.7575	495.1	6.000	126.770

13

ION IS 6 C 13					ION IS 7 N 14				
RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM	RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0607	1.7	5.451	7270.616	.0025	.0643	1.9	6.287	8806.204
.0050	.0790	2.9	5.732	5456.570	.0050	.0838	3.3	6.643	6629.790
.0075	.0909	3.9	5.833	4537.091	.0075	.0964	4.4	6.772	5499.953
.0100	.0999	4.7	5.882	3910.179	.0100	.1060	5.3	6.838	4750.225
.0200	.1233	7.2	5.953	2774.653	.0200	.1309	8.1	6.933	3421.702
.0300	.1383	9.0	5.974	2298.306	.0300	.1471	10.2	6.962	2822.330
.0400	.1501	10.7	5.984	2007.392	.0400	.1598	12.1	6.976	2459.238
.0500	.1598	12.1	5.989	1806.233	.0500	.1702	13.8	6.983	2211.743
.0600	.1682	13.5	5.992	1657.707	.0600	.1791	15.3	6.988	2029.352
.0700	.1755	14.7	5.994	1542.169	.0700	.1869	16.7	6.991	1887.654
.0800	.1821	15.8	5.995	1448.928	.0800	.1938	18.0	6.993	1773.452
.0900	.1881	16.9	5.996	1371.596	.0900	.2002	19.2	6.994	1678.758
.1000	.1936	17.9	5.997	1306.090	.1000	.2060	20.4	6.995	1598.626
.1500	.2159	22.5	5.999	1083.109	.1500	.2297	25.6	6.998	1326.732
.2000	.2332	26.4	5.999	949.454	.2000	.2479	30.0	6.999	1163.002
.3000	.2595	33.0	6.000	789.952	.3000	.2757	37.5	7.000	968.493
.4000	.2797	38.7	6.000	694.243	.4000	.2971	44.0	7.000	851.852
.5000	.2963	43.8	6.000	628.599	.5000	.3146	49.8	7.000	771.877
.6000	.3105	48.4	6.000	579.944	.6000	.3295	55.1	7.000	712.613
.7000	.3230	52.7	6.000	541.999	.7000	.3427	60.0	7.000	668.400
.8000	.3341	56.8	6.000	511.322	.8000	.3544	64.6	7.000	629.042
.9000	.3442	60.6	6.000	485.844	.9000	.3650	69.0	7.000	598.018
1.0000	.3535	64.3	6.000	464.241	1.0000	.3747	73.2	7.000	571.713
1.5000	.3910	80.6	6.000	390.563	1.5000	.4141	91.8	7.000	482.013
2.0000	.4196	94.7	6.000	346.313	2.0000	.4440	108.0	7.000	428.148
2.5000	.4428	107.4	6.000	315.949	2.5000	.4682	122.6	7.000	391.191
3.0000	.4625	119.1	6.000	293.438	3.0000	.4886	136.1	7.000	363.797
3.5000	.4796	130.0	6.000	275.881	3.5000	.5064	148.7	7.000	342.436
4.0000	.4948	140.3	6.000	261.687	4.0000	.5221	160.6	7.000	325.169
5.0000	.5208	159.6	6.000	239.908	5.0000	.5489	182.3	7.000	298.683
6.0000	.5426	177.4	6.000	223.770	6.0000	.5714	203.4	7.000	279.067
7.0000	.5615	194.1	6.000	211.193	7.0000	.5906	222.8	7.000	263.785
8.0000	.5780	209.9	6.000	201.032	8.0000	.6076	241.2	7.000	251.446
9.0000	.5928	225.1	6.000	192.601	9.0000	.6226	258.8	7.000	241.215
10.0000	.6062	239.6	6.000	185.460	10.0000	.6361	275.7	7.000	232.533
15.0000	.6583	305.8	6.000	161.195	15.0000	.6886	352.9	7.000	203.175
20.0000	.6955	364.8	6.000	146.741	20.0000	.7257	422.2	7.000	185.739
30.0000	.7474	470.5	6.000	129.713	30.0000	.7766	546.8	7.000	165.326

ION IS 7 N 15					ION IS 8 O 16				
RANGE	BETA	ENERGY	ZEFF	DE/DX	RANGE	BETA	ENERGY	ZEFF	DE/DX
(CM)	(V/C)	(MEV/AMU)		MEV/CM	(CM)	(V/C)	(MEV/AMU)		MEV/CM
.0025	.0625	1.8	6.240	9098.567	.0025	.0656	2.0	7.051	10806.409
.0050	.0817	3.1	6.616	6837.093	.0050	.0859	3.5	7.510	8097.150
.0075	.0942	4.2	6.754	5681.213	.0075	.0971	4.6	7.681	6717.998
.0100	.1036	5.0	6.824	4972.070	.0100	.1090	5.6	7.769	5853.541
.0200	.1283	7.8	6.927	3535.799	.0200	.1351	8.6	7.901	4239.938
.0300	.1442	9.8	6.958	2918.528	.0300	.1522	11.0	7.943	3486.231
.0400	.1567	11.6	6.973	2541.686	.0400	.1654	13.0	7.963	3032.051
.0500	.1669	13.3	6.981	2285.273	.0500	.1762	14.8	7.974	2725.519
.0600	.1757	14.7	6.986	2096.408	.0600	.1854	16.4	7.981	2499.575
.0700	.1833	16.1	6.990	1949.735	.0700	.1934	17.9	7.985	2324.346
.0800	.1902	17.3	6.992	1831.511	.0800	.2007	19.3	7.988	2183.249
.0900	.1964	18.5	6.993	1733.551	.0900	.2072	20.7	7.990	2066.426
.1000	.2022	19.6	6.995	1650.634	.1000	.2132	21.9	7.992	1967.603
.1500	.2255	24.6	6.998	1368.769	.1500	.2379	27.5	7.996	1632.050
.2000	.2434	28.9	6.999	1200.071	.2000	.2566	32.3	7.998	1431.467
.3000	.2708	36.1	7.000	998.957	.3000	.2853	40.4	7.999	1192.542
.4000	.2918	42.4	7.000	878.369	.4000	.3073	47.4	8.000	1049.371
.5000	.3091	47.9	7.000	795.694	.5000	.3254	53.6	8.000	951.244
.6000	.3238	53.0	7.000	734.431	.6000	.3408	59.3	8.000	878.546
.7000	.3367	57.8	7.000	686.661	.7000	.3543	64.6	8.000	821.867
.8000	.3483	62.2	7.000	648.045	.8000	.3664	69.6	8.000	776.053
.9000	.3588	66.4	7.000	615.978	.9000	.3773	74.3	8.000	738.011
1.0000	.3684	70.4	7.000	588.788	1.0000	.3873	78.8	8.000	705.758
1.5000	.4072	88.4	7.000	496.073	1.5000	.4277	99.0	8.000	575.789
2.0000	.4367	103.9	7.000	440.398	2.0000	.4583	116.5	8.000	529.766
2.5000	.4606	117.9	7.000	402.199	2.5000	.4831	132.3	8.000	484.474
3.0000	.4808	130.8	7.000	373.883	3.0000	.5040	146.9	8.000	450.907
3.5000	.4984	142.9	7.000	351.801	3.5000	.5221	160.6	8.000	424.734
4.0000	.5139	154.3	7.000	333.952	4.0000	.5380	173.5	8.000	403.583
5.0000	.5405	175.6	7.000	306.569	5.0000	.5653	197.7	8.000	371.146
6.0000	.5628	195.3	7.000	286.287	6.0000	.5880	220.1	8.000	347.130
7.0000	.5820	213.9	7.000	270.483	7.0000	.6076	241.2	8.000	328.428
8.0000	.5988	231.5	7.000	257.721	8.0000	.6246	261.2	8.000	313.334
9.0000	.6138	248.3	7.000	247.136	9.0000	.6398	280.4	8.000	300.823
10.0000	.6273	264.5	7.000	238.174	10.0000	.6534	298.8	8.000	290.236
15.0000	.6797	338.3	7.000	207.758	15.0000	.7059	383.4	8.000	254.377
20.0000	.7168	404.3	7.000	189.683	20.0000	.7427	459.3	8.000	233.152
30.0000	.7681	522.9	7.000	168.480	30.0000	.7928	596.5	8.000	208.419

ION IS 9 F 19					ION IS 10 NE 20				
RANGE	BETA	ENERGY	ZEFF	DE/DX	RANGE	BETA	ENERGY	ZEFF	DE/DX
(CM)	(V/C)	(MEV/AMU)		MEV/CM	(CM)	(V/C)	(MEV/AMU)		MEV/CM
.0025	.0652	2.0	7.730	13109.025	.0025	.0676	2.1	8.496	15004.318
.0050	.0861	3.5	8.323	9894.696	.0050	.0895	3.8	9.185	11312.617
.0075	.0996	4.7	8.548	8223.118	.0075	.1036	5.0	9.450	9390.801
.0100	.1098	5.7	8.667	7169.167	.0100	.1142	6.1	9.591	8216.637
.0200	.1365	8.8	8.851	5255.795	.0200	.1419	9.5	9.812	6026.241
.0300	.1541	11.3	8.912	4313.388	.0300	.1606	12.2	9.889	4962.933
.0400	.1677	13.4	8.942	3748.433	.0400	.1748	14.6	9.925	4312.279
.0500	.1787	15.2	8.958	3365.163	.0500	.1863	16.6	9.946	3871.090
.0600	.1882	16.9	8.968	3083.359	.0600	.1961	18.4	9.959	3546.846
.0700	.1964	18.5	8.975	2864.935	.0700	.2047	20.2	9.968	3295.624
.0800	.2038	20.0	8.980	2691.504	.0800	.2124	21.7	9.974	3093.571
.0900	.2105	21.3	8.984	2546.770	.0900	.2194	23.3	9.979	2928.027
.1000	.2166	22.6	8.987	2424.455	.1000	.2258	24.7	9.982	2787.343
.1500	.2416	28.4	8.994	2009.875	.1500	.2518	31.0	9.991	2311.065
.2000	.2607	33.4	8.996	1762.527	.2000	.2717	36.4	9.995	2027.271
.3000	.2899	41.8	8.999	1468.280	.3000	.3020	45.6	9.998	1689.958
.4000	.3123	49.0	8.999	1292.125	.4000	.3252	53.5	9.999	1488.148
.5000	.3306	55.5	9.000	1171.452	.5000	.3442	60.6	9.999	1349.945
.6000	.3463	61.4	9.000	1082.079	.6000	.3604	67.1	10.000	1247.610
.7000	.3600	66.9	9.000	1012.415	.7000	.3745	73.1	10.000	1167.852
.8000	.3722	72.1	9.000	956.113	.8000	.3872	78.8	10.000	1103.401
.9000	.3833	77.0	9.000	909.369	.9000	.3986	84.2	10.000	1049.894
1.0000	.3934	81.7	9.000	869.741	1.0000	.4091	89.3	10.000	1004.536
1.5000	.4343	102.6	9.000	734.653	1.5000	.4512	112.3	10.000	849.938
2.0000	.4653	120.8	9.000	653.565	2.0000	.4830	132.3	10.000	757.159
2.5000	.4903	137.2	9.000	597.947	2.5000	.5087	150.4	10.000	693.536
3.0000	.5114	152.4	9.000	556.732	3.0000	.5302	167.1	10.000	646.398
3.5000	.5296	166.6	9.000	524.600	3.5000	.5489	182.8	10.000	609.658
4.0000	.5457	180.1	9.000	498.635	4.0000	.5653	197.6	10.000	579.975
5.0000	.5732	205.2	9.000	458.822	5.0000	.5932	225.4	10.000	534.480
6.0000	.5961	228.5	9.000	429.352	6.0000	.6163	251.3	10.000	500.823
7.0000	.6157	250.5	9.000	406.407	7.0000	.6361	275.6	10.000	474.634
8.0000	.6328	271.4	9.000	387.893	8.0000	.6534	298.8	10.000	453.516
9.0000	.6480	291.4	9.000	372.551	9.0000	.6686	321.0	10.000	436.027
10.0000	.6616	310.6	9.000	359.572	10.0000	.6823	342.5	10.000	421.243
15.0000	.7141	398.9	9.000	315.641	15.0000	.7345	440.9	10.000	371.310
20.0000	.7507	478.3	9.000	289.679	20.0000	.7706	529.8	10.000	341.933
30.0000	.8003	622.0	9.000	259.503	30.0000	.8189	691.4	10.000	308.046

ION IS 10 NE 21					ION IS 10 NE 22				
RANGE	BETA	ENERGY	ZEFF	DE/DX	RANGE	BETA	ENERGY	ZEFF	DE/DX
(CM)	(V/C)	(MEV/AMU)		MEV/CM	(CM)	(V/C)	(MEV/AMU)		MEV/CM
.0025	.0662	2.0	8.434	15268.434	.0025	.0649	2.0	8.374	15514.993
.0050	.0879	3.6	9.147	11559.312	.0050	.0863	3.5	9.109	11797.238
.0075	.1018	4.9	9.423	9609.070	.0075	.1002	4.7	9.395	9820.614
.0100	.1123	5.9	9.570	8396.193	.0100	.1106	5.7	9.549	8566.643
.0200	.1399	9.2	9.801	6159.583	.0200	.1379	9.0	9.790	6289.187
.0300	.1583	11.9	9.881	5083.397	.0300	.1561	11.6	9.874	5201.179
.0400	.1723	14.1	9.920	4415.812	.0400	.1700	13.8	9.914	4517.030
.0500	.1837	16.1	9.942	3963.208	.0500	.1813	15.7	9.938	4053.252
.0600	.1935	17.9	9.956	3630.628	.0600	.1910	17.5	9.952	3712.512
.0700	.2020	19.6	9.965	3372.985	.0700	.1994	19.1	9.962	3448.583
.0800	.2096	21.2	9.972	3165.795	.0800	.2069	20.6	9.970	3236.365
.0900	.2165	22.6	9.977	2994.477	.0900	.2137	22.0	9.975	3060.908
.1000	.2228	24.0	9.981	2851.547	.1000	.2200	23.4	9.979	2914.277
.1500	.2485	30.2	9.991	2363.362	.1500	.2454	29.4	9.990	2414.431
.2000	.2682	35.4	9.995	2072.593	.2000	.2649	34.5	9.994	2116.838
.3000	.2982	44.4	9.998	1727.085	.3000	.2946	43.2	9.997	1763.320
.4000	.3211	52.1	9.999	1520.414	.4000	.3173	50.7	9.999	1551.900
.5000	.3399	59.0	9.999	1378.898	.5000	.3359	57.5	9.999	1407.149
.6000	.3560	65.3	10.000	1274.117	.6000	.3518	63.6	9.999	1299.980
.7000	.3700	71.1	10.000	1192.457	.7000	.3657	69.3	10.000	1216.463
.8000	.3825	76.6	10.000	1126.471	.8000	.3781	74.7	10.000	1148.978
.9000	.3938	81.9	10.000	1071.691	.9000	.3893	79.8	10.000	1092.956
1.0000	.4042	86.9	10.000	1025.255	1.0000	.3996	84.6	10.000	1045.468
1.5000	.4460	109.2	10.000	866.986	1.5000	.4411	106.4	10.000	883.617
2.0000	.4775	128.6	10.000	772.004	2.0000	.4723	125.3	10.000	786.487
2.5000	.5030	146.2	10.000	706.869	2.5000	.4976	142.3	10.000	719.877
3.0000	.5244	162.4	10.000	658.609	3.0000	.5189	158.1	10.000	670.522
3.5000	.5429	177.6	10.000	620.991	3.5000	.5373	172.9	10.000	632.050
4.0000	.5592	192.1	10.000	590.598	4.0000	.5535	186.9	10.000	600.964
5.0000	.5870	219.0	10.000	544.009	5.0000	.5812	213.1	10.000	553.308
6.0000	.6101	244.1	10.000	509.536	6.0000	.6042	237.4	10.000	518.041
7.0000	.6298	267.7	10.000	482.708	7.0000	.6239	260.3	10.000	490.590
8.0000	.6471	290.1	10.000	461.069	8.0000	.6410	282.1	10.000	468.445
9.0000	.6623	311.6	10.000	443.146	9.0000	.6563	302.9	10.000	450.098
10.0000	.6759	332.4	10.000	427.991	10.0000	.6699	323.0	10.000	434.583
15.0000	.7282	427.5	10.000	376.769	15.0000	.7223	415.2	10.000	382.108
20.0000	.7645	513.4	10.000	346.588	20.0000	.7587	498.3	10.000	351.149
30.0000	.8133	669.2	10.000	311.437	30.0000	.8079	648.9	10.000	315.267

| ION IS 11 NA 23 | | | | | | ION IS 12 MG 24 | | | | |
RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM		RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0671	2.1	9.112	17514.147		.0025	.0691	2.2	9.835	19562.593
.0050	.0895	3.7	9.952	13307.453		.0050	.0923	4.0	10.784	14846.538
.0075	.1038	5.1	10.282	11066.512		.0075	.1072	5.4	11.160	12353.605
.0100	.1147	6.2	10.460	9693.305		.0100	.1184	6.6	11.364	10856.891
.0200	.1430	9.7	10.743	7114.703		.0200	.1478	10.3	11.693	7952.470
.0300	.1620	12.5	10.844	5898.769		.0300	.1675	13.3	11.812	6579.700
.0400	.1765	14.9	10.894	5122.542		.0400	.1825	15.9	11.870	5751.252
.0500	.1883	17.0	10.922	4596.479		.0500	.1947	18.2	11.904	5160.675
.0600	.1983	18.9	10.940	4210.095		.0600	.2051	20.2	11.926	4726.995
.0700	.2071	20.6	10.952	3910.898		.0700	.2142	22.1	11.941	4391.245
.0800	.2149	22.3	10.961	3670.381		.0800	.2223	23.9	11.952	4121.199
.0900	.2220	23.8	10.968	3471.572		.0900	.2296	25.6	11.960	3998.387
.1000	.2285	25.3	10.973	3303.655		.1000	.2363	27.1	11.966	3710.056
.1500	.2549	31.8	10.986	2737.798		.1500	.2636	34.1	11.983	3074.400
.2000	.2751	37.4	10.992	2400.960		.2000	.2845	40.1	11.990	2696.767
.3000	.3058	46.8	10.996	2001.188		.3000	.3162	50.3	11.995	2248.990
.4000	.3293	55.0	10.998	1762.264		.4000	.3403	59.1	11.997	1981.554
.5000	.3485	62.3	10.999	1598.740		.5000	.3601	67.0	11.998	1798.580
.6000	.3649	69.0	10.999	1477.698		.6000	.3770	74.2	11.999	1663.169
.7000	.3792	75.2	10.999	1383.384		.7000	.3917	80.9	11.999	1557.676
.8000	.3920	81.0	11.000	1307.183		.8000	.4048	87.2	11.999	1472.453
.9000	.4036	86.6	11.000	1243.930		.9000	.4167	93.2	12.000	1401.719
1.0000	.4141	91.8	11.000	1190.317		1.0000	.4275	98.9	12.000	1341.766
1.5000	.4567	115.5	11.000	1007.619		1.5000	.4711	124.5	12.000	1137.505
2.0000	.4887	136.2	11.000	898.004		2.0000	.5033	146.8	12.000	1014.984
2.5000	.5146	154.8	11.000	822.848		2.5000	.5302	167.0	12.000	930.999
3.0000	.5363	172.1	11.000	767.174		3.0000	.5522	185.8	12.000	868.800
3.5000	.5551	188.3	11.000	723.785		3.5000	.5713	203.3	12.000	820.338
4.0000	.5715	203.6	11.000	688.735		4.0000	.5880	220.0	12.000	781.202
5.0000	.5996	232.3	11.000	635.023		5.0000	.6163	251.2	12.000	721.251
6.0000	.6228	259.0	11.000	595.296		6.0000	.6397	280.3	12.000	676.938
7.0000	.6427	284.2	11.000	564.392		7.0000	.6597	307.8	12.000	642.489
8.0000	.6599	308.2	11.000	539.478		8.0000	.6770	334.0	12.000	614.736
9.0000	.6752	331.2	11.000	518.851		9.0000	.6922	359.1	12.000	591.776
10.0000	.6888	353.4	11.000	501.419		10.0000	.7058	383.3	12.000	572.398
15.0000	.7409	455.3	11.000	442.590		15.0000	.7575	495.1	12.000	507.109
20.0000	.7768	547.5	11.000	408.036		20.0000	.7927	596.4	12.000	468.956
30.0000	.8247	715.3	11.000	368.294		30.0000	.8393	781.8	12.000	425.452

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ION IS 12 MG 25					ION IS 12 MG 26				
RANGE	BETA	ENERGY	ZEFF	DE/DX	RANGE	BETA	ENERGY	ZEFF	DE/DX
(CM)	(V/C)	(MEV/AMU)		MEV/CM	(CM)	(V/C)	(MEV/AMU)		MEV/CM
.0025	.0678	2.1	9.766	19839.467	.0025	.0666	2.1	9.697	20097.899
.0050	.0909	3.9	10.740	15134.529	.0050	.0895	3.7	10.696	15394.107
.0075	.1057	5.2	11.127	12592.158	.0075	.1042	5.1	11.095	12825.347
.0100	.1168	6.4	11.337	11054.286	.0100	.1152	6.2	11.312	11246.907
.0200	.1460	10.1	11.679	8105.257	.0200	.1441	9.8	11.663	8261.441
.0300	.1655	13.0	11.802	6706.568	.0300	.1635	12.7	11.792	6830.754
.0400	.1803	15.5	11.863	5867.013	.0400	.1782	15.2	11.856	5980.606
.0500	.1925	17.7	11.899	5263.595	.0500	.1903	17.3	11.893	5364.582
.0600	.2028	19.8	11.921	4820.528	.0600	.2005	19.3	11.917	4912.295
.0700	.2118	21.6	11.937	4477.547	.0700	.2094	21.1	11.933	4562.212
.0800	.2198	23.3	11.949	4201.918	.0800	.2174	22.8	11.945	4280.502
.0900	.2271	25.0	11.957	3974.148	.0900	.2246	24.4	11.954	4048.457
.1000	.2337	26.5	11.964	3781.817	.1000	.2312	25.9	11.961	3852.195
.1500	.2608	33.4	11.981	3131.425	.1500	.2581	32.6	11.980	3188.628
.2000	.2814	39.2	11.989	2747.075	.2000	.2785	38.4	11.988	2796.391
.3000	.3128	49.2	11.995	2290.103	.3000	.3097	48.1	11.994	2330.392
.4000	.3368	57.8	11.997	2017.242	.4000	.3335	56.5	11.997	2052.210
.5000	.3564	65.5	11.998	1830.581	.5000	.3529	64.0	11.998	1861.933
.6000	.3731	72.5	11.999	1692.453	.6000	.3695	70.9	11.999	1721.141
.7000	.3878	79.0	11.999	1584.850	.7000	.3840	77.3	11.999	1611.468
.8000	.4008	85.2	11.999	1497.924	.8000	.3969	83.3	11.999	1522.875
.9000	.4125	91.0	12.000	1425.779	.9000	.4086	89.0	12.000	1449.348
1.0000	.4233	96.6	12.000	1364.633	1.0000	.4193	94.5	12.000	1387.032
1.5000	.4666	121.6	12.000	1156.309	1.5000	.4623	118.9	12.000	1174.728
2.0000	.4991	143.4	12.000	1031.352	2.0000	.4946	140.2	12.000	1047.384
2.5000	.5253	163.1	12.000	945.695	2.5000	.5206	159.5	12.000	960.089
3.0000	.5473	181.4	12.000	882.253	3.0000	.5425	177.3	12.000	895.431
3.5000	.5662	198.5	12.000	832.820	3.5000	.5613	194.0	12.000	845.049
4.0000	.5828	214.8	12.000	792.897	4.0000	.5779	209.8	12.000	804.355
5.0000	.6111	245.2	12.000	731.733	5.0000	.6061	239.5	12.000	742.004
6.0000	.6345	273.5	12.000	686.514	6.0000	.6294	267.1	12.000	695.900
7.0000	.6544	300.2	12.000	651.354	7.0000	.6493	293.2	12.000	660.044
8.0000	.6717	325.7	12.000	623.022	8.0000	.6666	318.0	12.000	631.146
9.0000	.6869	350.1	12.000	599.577	9.0000	.6818	341.8	12.000	607.228
10.0000	.7006	373.7	12.000	579.774	10.0000	.6955	364.7	12.000	587.020
15.0000	.7523	482.3	12.000	513.048	15.0000	.7474	470.4	12.000	518.883
20.0000	.7878	530.7	12.000	473.986	20.0000	.7831	566.1	12.000	478.936
30.0000	.8349	760.4	12.000	429.317	30.0000	.8305	740.5	12.000	433.136

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\multicolumn{5}{c}{ION IS 13 AL 26}				
RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0696	2.3	10.469	21962.638
.0050	.0935	4.1	11.557	16758.990
.0075	.1088	5.6	11.993	13933.706
.0100	.1203	6.8	12.231	12270.910
.0200	.1505	10.7	12.622	8983.908
.0300	.1706	13.9	12.765	7434.193
.0400	.1859	16.5	12.836	6499.121
.0500	.1984	18.9	12.878	5855.297
.0600	.2091	21.0	12.905	5362.683
.0700	.2184	23.0	12.923	4981.401
.0800	.2267	24.9	12.937	4675.036
.0900	.2342	26.6	12.947	4421.902
.1000	.2411	28.3	12.955	4208.181
.1500	.2690	35.5	12.977	3485.665
.2000	.2902	41.9	12.986	3057.772
.3000	.3225	52.6	12.993	2550.404
.4000	.3472	61.8	12.996	2247.660
.5000	.3673	70.0	12.998	2040.632
.6000	.3845	77.5	12.998	1887.468
.7000	.3994	84.5	12.999	1768.169
.8000	.4128	91.2	12.999	1671.808
.9000	.4248	97.4	12.999	1591.839
1.0000	.4358	103.4	13.000	1524.069
1.5000	.4800	130.3	13.000	1293.213
2.0000	.5131	153.7	13.000	1154.779
2.5000	.5398	175.0	13.000	1059.908
3.0000	.5620	194.6	13.000	989.661
3.5000	.5812	213.1	13.000	934.940
4.0000	.5981	230.7	13.000	890.758
5.0000	.6265	263.6	13.000	823.100
6.0000	.6500	294.2	13.000	773.112
7.0000	.6700	323.2	13.000	734.270
8.0000	.6873	350.3	13.000	702.994
9.0000	.7026	377.3	13.000	677.133
10.0000	.7161	402.9	13.000	655.306
15.0000	.7674	521.2	13.000	581.943
20.0000	.8023	628.6	13.000	539.217
30.0000	.8480	825.7	13.000	490.805

ION IS 13 AL 27				
RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0684	2.2	10.395	22235.444
.0050	.0921	4.0	11.509	17036.333
.0075	.1073	5.4	11.958	14183.066
.0100	.1187	6.6	12.203	12476.574
.0200	.1487	10.5	12.606	9143.244
.0300	.1687	13.5	12.754	7566.510
.0400	.1839	16.1	12.828	6614.670
.0500	.1963	18.5	12.871	5963.303
.0600	.2069	20.6	12.900	5460.818
.0700	.2161	22.5	12.919	5071.927
.0800	.2243	24.4	12.933	4759.477
.0900	.2318	26.1	12.944	4501.335
.1000	.2386	27.7	12.952	4283.403
.1500	.2663	34.9	12.975	3546.777
.2000	.2874	41.0	12.985	3110.469
.3000	.3194	51.5	12.993	2593.414
.4000	.3439	60.5	12.996	2284.972
.5000	.3638	68.5	12.997	2074.076
.6000	.3809	75.9	12.998	1918.065
.7000	.3957	82.8	12.999	1796.555
.8000	.4090	89.2	12.999	1698.413
.9000	.4209	95.4	12.999	1616.968
1.0000	.4318	101.2	12.999	1547.948
1.5000	.4758	127.5	13.000	1312.844
2.0000	.5087	150.4	13.000	1171.862
2.5000	.5352	171.2	13.000	1075.242
3.0000	.5574	190.4	13.000	1003.696
3.5000	.5765	208.4	13.000	947.959
4.0000	.5933	225.6	13.000	902.954
5.0000	.6217	257.7	13.000	834.025
6.0000	.6452	287.6	13.000	783.089
7.0000	.6651	315.8	13.000	743.502
8.0000	.6824	342.7	13.000	711.618
9.0000	.6977	368.6	13.000	685.248
10.0000	.7113	393.5	13.000	662.986
15.0000	.7627	508.7	13.000	588.099
20.0000	.7978	613.2	13.000	544.411
30.0000	.8439	804.6	13.000	494.756

ION IS 14 SI 28					ION IS 15 P 31				
RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM	RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0700	2.3	11.079	24421.671	.0025	.0693	2.2	11.588	27205.675
.0050	.0945	4.2	12.313	18723.077	.0050	.0942	4.2	12.999	21048.730
.0075	.1102	5.7	12.812	15577.907	.0075	.1102	5.7	13.578	17550.231
.0100	.1220	7.0	13.087	13744.305	.0100	.1222	7.0	13.898	15496.013
.0200	.1530	11.1	13.543	10058.955	.0200	.1536	11.2	14.438	11347.990
.0300	.1735	14.3	13.712	8324.988	.0300	.1745	14.5	14.640	9393.638
.0400	.1891	17.1	13.797	7278.716	.0400	.1903	17.3	14.743	8213.786
.0500	.2019	19.6	13.847	6560.044	.0500	.2032	19.8	14.805	7403.235
.0600	.2128	21.8	13.880	6027.382	.0600	.2142	22.1	14.846	6802.339
.0700	.2223	23.9	13.903	5598.521	.0700	.2239	24.2	14.875	6340.300
.0800	.2308	25.8	13.920	5253.988	.0800	.2325	26.2	14.896	5949.367
.0900	.2384	27.7	13.933	4969.369	.0900	.2402	28.1	14.912	5626.479
.1000	.2455	29.4	13.942	4729.107	.1000	.2473	29.9	14.924	5353.966
.1500	.2739	37.0	13.970	3917.193	.1500	.2762	37.7	14.959	4433.508
.2000	.2956	43.6	13.981	3435.023	.2000	.2981	44.4	14.974	3887.254
.3000	.3285	54.7	13.991	2865.904	.3000	.3313	55.7	14.987	3241.827
.4000	.3536	64.3	13.995	2526.238	.4000	.3566	65.5	14.993	2857.415
.5000	.3741	72.9	13.997	2294.082	.5000	.3773	74.3	14.995	2594.860
.6000	.3915	80.8	13.998	2122.383	.6000	.3949	82.4	14.997	2400.765
.7000	.4067	88.1	13.998	1988.679	.7000	.4102	89.8	14.998	2249.666
.8000	.4202	95.0	13.999	1880.700	.8000	.4238	96.9	14.998	2127.667
.9000	.4324	101.5	13.999	1791.101	.9000	.4361	103.6	14.999	2026.451
1.0000	.4436	107.8	13.999	1715.178	1.0000	.4474	110.0	14.999	1940.696
1.5000	.4884	135.9	14.000	1456.608	1.5000	.4924	138.7	15.000	1648.718
2.0000	.5219	160.4	14.000	1301.601	2.0000	.5261	163.8	15.000	1473.739
2.5000	.5487	182.7	14.000	1195.397	2.5000	.5531	186.5	15.000	1353.876
3.0000	.5712	203.3	14.000	1116.775	3.0000	.5757	207.6	15.000	1265.157
3.5000	.5905	222.7	14.000	1055.544	3.5000	.5951	227.4	15.000	1196.073
4.0000	.6074	241.0	14.000	1006.116	4.0000	.6120	246.3	15.000	1140.314
5.0000	.6360	275.5	14.000	930.449	5.0000	.6407	281.6	15.000	1054.972
6.0000	.6596	307.7	14.000	874.571	6.0000	.6643	314.6	15.000	991.966
7.0000	.6796	338.2	14.000	831.173	7.0000	.6843	345.8	15.000	943.047
8.0000	.6969	367.2	14.000	796.247	8.0000	.7016	375.5	15.000	903.688
9.0000	.7121	395.1	14.000	767.384	9.0000	.7167	404.1	15.000	871.171
10.0000	.7256	422.1	14.000	743.039	10.0000	.7302	431.8	15.000	843.751
15.0000	.7765	546.7	14.000	661.347	15.0000	.7810	559.7	15.000	751.935
20.0000	.8110	660.2	14.000	613.947	20.0000	.8151	676.3	15.000	698.609
30.0000	.8558	868.9	14.000	560.597	30.0000	.8596	890.9	15.000	639.915

ION IS 16 S 32					ION IS 17 CL 35				
RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM	RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0707	2.3	12.235	29499.179	.0025	.0699	2.3	12.697	32361.057
.0050	.0964	4.4	13.775	22851.555	.0050	.0960	4.3	14.425	25315.949
.0075	.1128	6.0	14.410	19094.944	.0075	.1127	6.0	15.145	21200.317
.0100	.1250	7.4	14.763	16860.812	.0100	.1251	7.4	15.548	18735.269
.0200	.1574	11.8	15.363	12334.516	.0200	.1580	11.8	16.239	13716.043
.0300	.1788	15.2	15.588	10211.133	.0300	.1796	15.4	16.503	11356.970
.0400	.1950	18.2	15.705	8929.726	.0400	.1960	18.4	16.640	9932.552
.0500	.2082	20.9	15.775	8049.623	.0500	.2094	21.1	16.723	8954.065
.0600	.2195	23.3	15.821	7397.273	.0600	.2208	23.6	16.779	8228.757
.0700	.2294	25.5	15.854	6888.752	.0700	.2308	25.8	16.818	7663.360
.0800	.2382	27.6	15.878	6484.780	.0800	.2396	27.9	16.847	7206.547
.0900	.2462	29.6	15.896	6133.319	.0900	.2477	30.0	16.870	6827.444
.1000	.2535	31.4	15.911	5836.703	.1000	.2551	31.9	16.887	6510.184
.1500	.2830	39.7	15.951	4834.962	.1500	.2850	40.3	16.937	5391.612
.2000	.3055	46.8	15.969	4240.598	.2000	.3077	47.5	16.960	4728.280
.3000	.3395	58.8	15.985	3537.283	.3000	.3420	59.7	16.980	3943.767
.4000	.3653	69.1	15.991	3119.667	.4000	.3681	70.3	16.988	3476.649
.5000	.3864	78.4	15.994	2834.120	.5000	.3893	79.8	16.992	3159.073
.6000	.4043	86.9	15.996	2623.082	.6000	.4074	88.4	16.994	2923.915
.7000	.4200	94.9	15.997	2458.824	.7000	.4231	96.5	16.996	2740.944
.8000	.4339	102.3	15.998	2326.219	.8000	.4371	104.1	16.997	2593.267
.9000	.4464	109.4	15.998	2216.216	.9000	.4497	111.4	16.998	2470.786
1.0000	.4578	116.2	15.999	2123.025	1.0000	.4612	118.3	16.998	2367.038
1.5000	.5036	146.7	15.999	1805.798	1.5000	.5072	149.3	16.999	2013.977
2.0000	.5377	173.3	16.000	1615.748	2.0000	.5415	176.5	17.000	1802.532
2.5000	.5651	197.5	16.000	1485.600	2.5000	.5689	201.1	17.000	1657.765
3.0000	.5878	219.9	16.000	1389.297	3.0000	.5918	224.0	17.000	1550.664
3.5000	.6074	241.0	16.000	1314.330	3.5000	.6114	245.5	17.000	1467.305
4.0000	.6245	261.0	16.000	1253.842	4.0000	.6285	266.0	17.000	1400.056
5.0000	.6533	298.7	16.000	1161.307	5.0000	.6573	304.4	17.000	1297.200
6.0000	.6769	333.9	16.000	1093.039	6.0000	.6810	340.4	17.000	1221.339
7.0000	.6969	367.2	16.000	1040.074	7.0000	.7009	374.4	17.000	1162.501
8.0000	.7141	399.0	16.000	997.494	8.0000	.7181	406.9	17.000	1115.214
9.0000	.7292	429.6	16.000	962.346	9.0000	.7332	438.2	17.000	1076.193
10.0000	.7426	459.2	16.000	932.735	10.0000	.7466	468.5	17.000	1043.329
15.0000	.7927	596.4	16.000	833.742	15.0000	.7965	608.8	17.000	933.574
20.0000	.8262	721.8	16.000	776.756	20.0000	.8298	737.4	17.000	870.530
30.0000	.8574	953.5	16.000	713.543	30.0000	.8726	974.9	17.000	800.876

| ION IS 18 AR 36 | | | | | ION IS 18 AR 38 | | | | |
RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM	RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0711	2.4	13.311	34738.415	.0025	.0691	2.2	13.135	35228.318
.0050	.0978	4.5	15.175	27224.506	.0050	.0956	4.3	15.055	27841.277
.0075	.1149	6.2	15.956	22844.275	.0075	.1126	6.0	15.864	23369.675
.0100	.1277	7.7	16.394	20191.112	.0100	.1252	7.4	16.318	20670.419
.0200	.1614	12.4	17.152	14769.619	.0200	.1586	11.9	17.105	15144.687
.0300	.1835	16.1	17.442	12230.434	.0300	.1805	15.5	17.409	12542.308
.0400	.2003	19.3	17.594	10697.739	.0400	.1971	18.6	17.568	10970.115
.0500	.2140	22.1	17.686	9645.095	.0500	.2106	21.4	17.666	9889.920
.0600	.2256	24.6	17.748	8864.931	.0600	.2221	23.9	17.731	9089.179
.0700	.2358	27.0	17.792	8256.835	.0700	.2322	26.2	17.778	8464.975
.0800	.2449	29.2	17.825	7765.564	.0800	.2412	28.3	17.813	7960.656
.0900	.2531	31.3	17.850	7357.888	.0900	.2493	30.4	17.839	7542.134
.1000	.2606	33.3	17.870	7012.467	.1000	.2567	32.3	17.860	7187.514
.1500	.2912	42.2	17.927	5822.592	.1500	.2869	40.9	17.921	5969.110
.2000	.3144	49.7	17.953	5107.827	.2000	.3099	48.2	17.949	5234.258
.3000	.3494	62.6	17.976	4262.610	.3000	.3445	60.7	17.974	4365.561
.4000	.3759	73.7	17.985	3759.428	.4000	.3708	71.5	17.984	3848.552
.5000	.3976	83.7	17.990	3416.862	.5000	.3923	81.1	17.989	3495.734
.6000	.4159	92.8	17.993	3163.554	.6000	.4104	90.0	17.992	3236.300
.7000	.4319	101.3	17.995	2966.500	.7000	.4263	98.2	17.994	3033.916
.8000	.4462	109.3	17.996	2807.481	.8000	.4404	106.0	17.996	2870.614
.9000	.4590	116.9	17.997	2675.609	.9000	.4530	113.3	17.997	2735.200
1.0000	.4706	124.2	17.998	2563.919	1.0000	.4646	120.4	17.997	2620.516
1.5000	.5173	156.9	17.999	2183.918	1.5000	.5109	152.0	17.999	2230.354
2.0000	.5520	185.5	17.999	1956.419	2.0000	.5454	179.7	17.999	1996.774
2.5000	.5796	211.6	18.000	1800.709	2.5000	.5729	204.9	18.000	1836.890
3.0000	.6027	235.7	18.000	1635.550	3.0000	.5958	228.3	18.000	1718.629
3.5000	.6224	258.5	18.000	1595.948	3.5000	.6154	250.2	18.000	1626.600
4.0000	.6396	280.1	18.000	1523.687	4.0000	.6326	271.1	18.000	1552.362
5.0000	.6685	320.8	18.000	1413.221	5.0000	.6615	310.4	18.000	1438.856
6.0000	.6921	358.9	18.000	1331.809	6.0000	.6851	347.1	18.000	1355.162
7.0000	.7120	395.0	18.000	1268.715	7.0000	.7051	381.9	18.000	1290.269
8.0000	.7292	429.5	18.000	1218.052	8.0000	.7222	415.2	18.000	1238.133
9.0000	.7441	462.8	18.000	1176.282	9.0000	.7373	447.2	18.000	1195.124
10.0000	.7574	494.9	18.000	1141.136	10.0000	.7506	478.1	18.000	1158.915
15.0000	.8067	644.4	18.000	1024.105	15.0000	.8003	621.8	18.000	1038.117
20.0000	.8393	781.6	18.000	957.313	20.0000	.8334	753.5	18.000	968.889
30.0000	.8809	1036.2	18.000	884.421	30.0000	.8757	997.2	18.000	892.737

ION IS 18 AR 40

RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0673	2.1	12.964	35669.396
.0050	.0936	4.1	14.932	28427.286
.0075	.1104	5.7	15.773	23870.229
.0100	.1229	7.1	16.244	21133.625
.0200	.1559	11.5	17.059	15508.841
.0300	.1776	15.0	17.376	12845.550
.0400	.1940	18.0	17.543	11235.059
.0500	.2074	20.7	17.645	10128.127
.0600	.2188	23.1	17.714	9307.397
.0700	.2288	25.4	17.763	8667.536
.0800	.2377	27.5	17.800	8150.528
.0900	.2457	29.5	17.828	7721.458
.1000	.2531	31.3	17.850	7357.888
.1500	.2830	39.7	17.915	6111.936
.2000	.3057	46.8	17.945	5352.473
.3000	.3400	59.0	17.971	4465.858
.4000	.3660	69.4	17.982	3935.358
.5000	.3872	78.8	17.988	3573.400
.6000	.4053	87.4	17.992	3307.137
.7000	.4210	95.4	17.994	3099.556
.8000	.4349	102.9	17.995	2932.078
.9000	.4475	110.1	17.996	2793.211
1.0000	.4590	116.9	17.997	2675.609
1.5000	.5049	147.6	17.999	2275.553
2.0000	.5391	174.4	17.999	2036.056
2.5000	.5665	198.8	18.000	1872.113
3.0000	.5893	221.4	18.000	1750.836
3.5000	.6089	242.7	18.000	1656.449
4.0000	.6260	262.9	18.000	1580.301
5.0000	.6540	300.9	18.000	1463.833
6.0000	.6785	336.3	18.000	1372.926
7.0000	.6984	369.9	18.000	1311.288
8.0000	.7157	402.0	18.000	1257.726
9.0000	.7308	432.9	18.000	1213.519
10.0000	.7441	462.8	18.000	1176.282
15.0000	.7942	601.2	18.000	1051.850
20.0000	.8276	727.8	18.000	980.284
30.0000	.8707	961.8	18.000	901.024

ION IS 19 K 39

RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0702	2.3	13.729	37643.177
.0050	.0974	4.4	15.790	29311.808
.0075	.1148	6.2	16.662	25072.333
.0100	.1277	7.7	17.153	22180.219
.0200	.1619	12.4	18.011	16238.803
.0300	.1842	16.2	18.342	13449.593
.0400	.2012	19.4	18.517	11764.982
.0500	.2150	22.3	18.625	10607.795
.0600	.2267	24.9	18.697	9750.102
.0700	.2370	27.3	18.749	9081.572
.0800	.2462	29.6	18.788	8541.482
.0900	.2545	31.7	18.818	8093.302
.1000	.2621	33.7	18.841	7713.568
.1500	.2929	42.7	18.910	6417.641
.2000	.3163	50.4	18.941	5629.311
.3000	.3516	63.5	18.969	4697.502
.4000	.3784	74.8	18.981	4143.005
.5000	.4002	84.9	18.987	3764.643
.6000	.4186	94.2	18.991	3486.004
.7000	.4348	102.8	18.993	3268.964
.8000	.4490	111.0	18.995	3093.863
.9000	.4619	118.7	18.996	2948.683
1.0000	.4737	126.1	18.997	2825.742
1.5000	.5205	159.4	18.999	2407.592
2.0000	.5554	188.5	18.999	2157.346
2.5000	.5831	215.0	19.000	1986.111
3.0000	.6062	239.7	19.000	1859.493
3.5000	.6260	262.8	19.000	1760.992
4.0000	.6432	284.9	19.000	1681.567
5.0000	.6721	326.4	19.000	1560.177
6.0000	.6957	365.2	19.000	1470.741
7.0000	.7156	402.0	19.000	1401.451
8.0000	.7327	437.2	19.000	1345.829
9.0000	.7477	471.1	19.000	1299.987
10.0000	.7609	503.9	19.000	1261.429
15.0000	.8100	656.5	19.000	1133.170
20.0000	.8424	796.7	19.000	1060.141
30.0000	.8836	1057.1	19.000	930.801

ION IS	20 CA 40				ION IS	20 CA 44			
RANGE	BETA	ENERGY	ZEFF	DE/DX	RANGE	BETA	ENERGY	ZEFF	DE/DX
(CM)	(V/C)	(MEV/AMU)		MEV/CM	(CM)	(V/C)	(MEV/AMU)		MEV/CM
.0025	.0713	2.4	14.311	40082.831	.0025	.0677	2.1	13.945	40938.605
.0050	.0991	4.6	16.516	31816.576	.0050	.0950	4.2	16.260	33054.919
.0075	.1168	6.4	17.452	26809.513	.0075	.1125	6.0	17.254	27888.438
.0100	.1300	8.0	17.982	23721.824	.0100	.1256	7.4	17.818	24714.200
.0200	.1650	12.9	18.911	17356.243	.0200	.1599	12.1	18.808	18138.776
.0300	.1878	16.9	19.272	14376.466	.0300	.1823	15.9	19.198	15028.088
.0400	.2051	20.2	19.463	12577.201	.0400	.1992	19.1	19.405	13146.447
.0500	.2192	23.2	19.581	11341.478	.0500	.2131	21.9	19.534	11853.177
.0600	.2311	25.9	19.661	10425.693	.0600	.2248	24.5	19.621	10894.376
.0700	.2416	28.4	19.718	9711.950	.0700	.2351	26.9	19.684	10146.946
.0800	.2510	30.8	19.761	9135.374	.0800	.2443	29.1	19.731	9543.079
.0900	.2594	33.0	19.794	8656.944	.0900	.2526	31.2	19.768	9041.963
.1000	.2671	35.1	19.821	8251.598	.1000	.2601	33.2	19.797	8617.375
.1500	.2985	44.5	19.897	6876.852	.1500	.2909	42.1	19.882	7172.282
.2000	.3224	52.5	19.932	6033.958	.2000	.3143	49.7	19.922	6299.547
.3000	.3583	66.2	19.964	5037.746	.3000	.3496	62.7	19.958	5253.844
.4000	.3856	78.0	19.978	4444.993	.4000	.3764	73.9	19.974	4631.967
.5000	.4077	88.6	19.985	4040.565	.5000	.3982	83.9	19.982	4207.813
.6000	.4265	98.3	19.989	3741.901	.6000	.4166	93.1	19.987	3894.655
.7000	.4428	107.4	19.992	3510.395	.7000	.4327	101.7	19.990	3651.139
.8000	.4573	115.9	19.994	3323.243	.8000	.4469	109.8	19.992	3455.558
.9000	.4704	124.0	19.995	3168.094	.9000	.4598	117.4	19.994	3292.942
1.0000	.4823	131.8	19.996	3036.725	1.0000	.4715	124.7	19.995	3155.267
1.5000	.5297	166.7	19.998	2590.021	1.5000	.5183	157.7	19.998	2687.191
2.0000	.5648	197.2	19.999	2322.788	2.0000	.5531	186.5	19.999	2407.184
2.5000	.5928	225.1	19.999	2139.990	2.5000	.5808	212.7	19.999	2215.619
3.0000	.6160	250.9	20.000	2004.868	3.0000	.6039	237.0	20.000	2073.983
3.5000	.6359	275.3	20.000	1899.788	3.5000	.6236	260.0	20.000	1963.804
4.0000	.6531	298.5	20.000	1815.088	4.0000	.6408	281.8	20.000	1874.962
5.0000	.6821	342.2	20.000	1685.705	5.0000	.6697	322.7	20.000	1739.175
6.0000	.7057	383.1	20.000	1590.455	6.0000	.6934	361.1	20.000	1639.124
7.0000	.7255	421.9	20.000	1516.722	7.0000	.7133	397.4	20.000	1561.599
8.0000	.7425	459.0	20.000	1457.588	8.0000	.7304	432.2	20.000	1499.358
9.0000	.7574	494.9	20.000	1408.897	9.0000	.7454	465.6	20.000	1448.051
10.0000	.7705	529.6	20.000	1367.983	10.0000	.7586	498.1	20.000	1404.888
15.0000	.8189	691.2	20.000	1232.316	15.0000	.8078	648.7	20.000	1261.220
20.0000	.8502	840.0	20.000	1155.607	20.0000	.8404	787.0	20.000	1179.297
30.0000	.8907	1117.3	20.000	1073.414	30.0000	.8818	1043.6	20.000	1090.042

ION IS	20 CA 48			
RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0646	1.9	13.600	41614.224
.0050	.0914	3.9	16.014	34177.052
.0075	.1087	5.5	17.061	28931.610
.0100	.1216	7.0	17.658	25647.291
.0200	.1553	11.4	18.708	18881.831
.0300	.1773	15.0	19.124	15648.532
.0400	.1940	18.0	19.348	13689.038
.0500	.2076	20.7	19.487	12341.172
.0600	.2192	23.2	19.581	11341.478
.0700	.2293	25.5	19.650	10561.983
.0800	.2383	27.6	19.701	9932.118
.0900	.2464	29.6	19.741	9409.379
.1000	.2539	31.5	19.773	8966.445
.1500	.2841	40.0	19.867	7458.805
.2000	.3071	47.3	19.911	6553.606
.3000	.3418	59.7	19.952	5460.437
.4000	.3681	70.3	19.970	4810.648
.5000	.3896	79.9	19.979	4367.600
.6000	.4077	88.6	19.985	4040.565
.7000	.4236	96.8	19.989	3786.301
.8000	.4376	104.4	19.991	3581.229
.9000	.4503	111.7	19.993	3412.156
1.0000	.4618	118.7	19.994	3268.448
1.5000	.5080	149.9	19.997	2779.950
2.0000	.5424	177.2	19.999	2487.752
2.5000	.5699	202.0	19.999	2287.830
3.0000	.5928	225.1	19.999	2139.990
3.5000	.6124	246.7	20.000	2024.958
4.0000	.6296	267.3	20.000	1932.178
5.0000	.6584	306.0	20.000	1790.310
6.0000	.6821	342.2	20.000	1685.705
7.0000	.7021	376.4	20.000	1604.589
8.0000	.7193	409.2	20.000	1539.411
9.0000	.7343	440.7	20.000	1485.635
10.0000	.7477	471.1	20.000	1440.352
15.0000	.7926	612.4	20.000	1289.178
20.0000	.8303	741.9	20.000	1202.409
30.0000	.8734	981.2	20.000	1106.667

ION IS	21 SC 45			
RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0687	2.2	14.502	45408.770
.0050	.0966	4.4	16.966	35177.850
.0075	.1145	6.2	18.028	29700.702
.0100	.1278	7.7	18.632	26326.047
.0200	.1629	12.6	19.699	19310.500
.0300	.1857	16.5	20.120	16000.199
.0400	.2030	19.8	20.345	13998.230
.0500	.2171	22.8	20.485	12622.848
.0600	.2291	25.4	20.580	11602.855
.0700	.2396	27.9	20.649	10807.950
.0800	.2489	30.3	20.701	10165.822
.0900	.2573	32.5	20.741	9632.973
.1000	.2651	34.5	20.773	9181.554
.1500	.2964	43.8	20.867	7645.000
.2000	.3202	51.8	20.911	6724.450
.3000	.3561	65.3	20.952	5611.037
.4000	.3833	77.0	20.970	4948.700
.5000	.4055	87.5	20.979	4492.413
.6000	.4242	97.1	20.985	4164.057
.7000	.4405	106.0	20.989	3904.000
.8000	.4550	114.5	20.991	3695.777
.9000	.4680	122.5	20.993	3523.246
1.0000	.4798	130.2	20.994	3376.707
1.5000	.5272	164.6	20.997	2878.623
2.0000	.5623	194.8	20.999	2580.777
2.5000	.5902	222.3	20.999	2377.076
3.0000	.6134	247.9	20.999	2226.516
3.5000	.6332	271.9	21.000	2109.433
4.0000	.6505	294.8	21.000	2015.058
5.0000	.6794	337.9	21.000	1870.854
6.0000	.7031	378.3	21.000	1764.755
7.0000	.7229	416.5	21.000	1682.548
8.0000	.7400	453.2	21.000	1516.017
9.0000	.7548	488.5	21.000	1562.355
10.0000	.7680	522.7	21.000	1516.670
15.0000	.8165	681.9	21.000	1360.144
20.0000	.8485	828.4	21.000	1279.454
30.0000	.8889	1101.2	21.000	1182.179

ION IS 22 TI 46					ION IS 22 TI 48				
RANGE	BETA	ENERGY	ZEFF	DE/DX	RANGE	BETA	ENERGY	ZEFF	DE/DX
(CM)	(V/C)	(MEV/AMU)		MEV/CM	(CM)	(V/C)	(MEV/AMU)		MEV/CM
.0025	.0696	2.3	15.048	45884.853	.0025	.0680	2.2	14.859	46242.307
.0050	.0981	4.5	17.664	37250.481	.0050	.0962	4.3	17.529	37866.392
.0075	.1163	6.4	18.794	31544.890	.0075	.1144	6.1	18.688	32095.520
.0100	.1299	8.0	19.439	27967.514	.0100	.1279	7.7	19.351	28478.725
.0200	.1657	13.1	20.585	20504.336	.0200	.1634	12.7	20.529	20911.028
.0300	.1890	17.1	21.038	16990.954	.0300	.1865	16.6	20.997	17330.142
.0400	.2066	20.5	21.281	14866.665	.0400	.2040	20.0	21.249	15163.093
.0500	.2210	23.6	21.433	13407.120	.0500	.2182	23.0	21.407	13673.607
.0600	.2332	26.4	21.537	12325.319	.0600	.2303	25.7	21.514	12569.402
.0700	.2438	29.0	21.612	11482.161	.0700	.2409	28.2	21.592	11708.692
.0800	.2533	31.4	21.668	10801.050	.0800	.2503	30.6	21.651	11013.358
.0900	.2619	33.7	21.712	10235.897	.0900	.2588	32.8	21.697	10436.381
.1000	.2698	35.9	21.747	9757.093	.1000	.2666	35.0	21.734	9947.549
.1500	.3016	45.5	21.851	8127.732	.1500	.2982	44.4	21.842	8284.022
.2000	.3259	53.8	21.900	7158.498	.2000	.3222	52.5	21.894	7297.405
.3000	.3624	67.9	21.945	5976.192	.3000	.3584	66.3	21.942	6089.148
.4000	.3900	80.1	21.965	5273.186	.4000	.3858	78.2	21.963	5370.875
.5000	.4125	91.0	21.976	4793.766	.5000	.4081	88.8	21.974	4881.120
.6000	.4315	101.0	21.983	4439.851	.6000	.4270	98.6	21.981	4519.614
.7000	.4480	110.4	21.987	4164.675	.7000	.4434	107.7	21.986	4238.556
.8000	.4626	119.2	21.990	3942.735	.8000	.4579	116.3	21.989	4011.886
.9000	.4758	127.5	21.992	3758.781	.9000	.4710	124.4	21.991	3824.018
1.0000	.4878	135.5	21.993	3603.739	1.0000	.4829	132.2	21.993	3665.605
1.5000	.5356	171.5	21.997	3075.108	1.5000	.5305	167.3	21.997	3125.770
2.0000	.5710	203.1	21.998	2759.120	2.0000	.5657	198.1	21.998	2803.094
2.5000	.5992	231.9	21.999	2543.088	2.5000	.5938	226.1	21.999	2582.474
3.0000	.6225	258.6	21.999	2383.467	3.0000	.6170	252.1	21.999	2419.443
3.5000	.6424	283.8	21.999	2259.380	3.5000	.6369	276.6	21.999	2292.637
4.0000	.6597	307.8	22.000	2159.393	4.0000	.6541	299.9	22.000	2190.532
5.0000	.6886	353.0	22.000	2006.734	5.0000	.6831	343.8	22.000	2034.518
6.0000	.7122	395.3	22.000	1894.422	6.0000	.7067	385.0	22.000	1919.689
7.0000	.7320	435.5	22.000	1807.539	7.0000	.7266	424.0	22.000	1830.816
8.0000	.7489	474.1	22.000	1737.907	8.0000	.7436	461.4	22.000	1759.550
9.0000	.7637	511.2	22.000	1680.613	9.0000	.7584	497.4	22.000	1700.880
10.0000	.7767	547.2	22.000	1632.507	10.0000	.7715	532.3	22.000	1651.589
15.0000	.8247	715.0	22.000	1473.363	15.0000	.8198	694.9	22.000	1488.212
20.0000	.8560	869.9	22.000	1383.849	20.0000	.8515	844.7	22.000	1395.918
30.0000	.8953	1159.1	22.000	1288.934	30.0000	.8915	1124.0	22.000	1297.190

ION IS 23 V 51						ION IS 24 CR 50				
RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM		RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0673	2.1	15.178	49043.061		.0025	.0696	2.3	15.907	51234.650
.0050	.0959	4.3	18.074	40632.885		.0050	.0990	4.6	18.888	42216.798
.0075	.1143	6.1	19.335	34540.194		.0075	.1178	6.5	20.191	35913.413
.0100	.1279	7.7	20.058	30682.024		.0100	.1318	8.2	20.939	31884.523
.0200	.1639	12.8	21.350	22553.404		.0200	.1688	13.6	22.283	23393.433
.0300	.1873	16.8	21.867	18695.559		.0300	.1928	17.8	22.819	19391.211
.0400	.2050	20.2	22.147	16359.180		.0400	.2109	21.4	23.110	16969.960
.0500	.2193	23.2	22.323	14752.935		.0500	.2256	24.6	23.293	15306.224
.0600	.2315	26.0	22.443	13562.080		.0600	.2381	27.6	23.418	14073.110
.0700	.2422	28.6	22.531	12633.807		.0700	.2490	30.3	23.510	13112.075
.0800	.2517	31.0	22.598	11883.894		.0800	.2587	32.8	23.579	12335.793
.0900	.2603	33.2	22.649	11261.636		.0900	.2675	35.2	23.633	11691.711
.1000	.2681	35.4	22.691	10734.451		.1000	.2756	37.5	23.676	11146.070
.1500	.3000	45.0	22.815	8940.499		.1500	.3082	47.6	23.805	9289.490
.2000	.3242	53.2	22.874	7866.535		.2000	.3329	56.3	23.868	8178.111
.3000	.3607	67.2	22.930	6581.154		.3000	.3702	71.2	23.926	6851.303
.4000	.3883	79.3	22.955	5805.141		.4000	.3985	84.1	23.953	6047.938
.5000	.4107	90.1	22.969	5276.122		.5000	.4213	95.6	23.967	5500.223
.6000	.4297	100.1	22.977	4885.695		.6000	.4407	106.2	23.975	5095.979
.7000	.4462	109.3	22.982	4582.192		.7000	.4575	116.0	23.981	4781.729
.8000	.4609	118.1	22.986	4337.445		.8000	.4724	125.3	23.985	4528.315
.9000	.4741	126.4	22.989	4134.614		.9000	.4858	134.2	23.988	4318.305
1.0000	.4860	134.3	22.991	3962.932		1.0000	.4980	142.6	23.990	4140.550
1.5000	.5338	170.0	22.996	3380.542		1.5000	.5465	180.7	23.995	3537.433
2.0000	.5692	201.3	22.998	3032.364		2.0000	.5822	214.2	23.997	3177.072
2.5000	.5973	229.8	22.998	2794.376		2.5000	.6106	244.6	23.998	2930.862
3.0000	.6206	256.3	22.999	2618.553		3.0000	.6341	273.0	23.999	2749.049
3.5000	.6405	281.3	22.999	2491.878		3.5000	.6540	299.7	23.999	2607.790
4.0000	.6578	305.1	22.999	2371.749		4.0000	.6714	325.2	23.999	2494.028
5.0000	.6867	349.8	23.000	2203.602		5.0000	.7003	373.3	24.000	2320.480
6.0000	.7103	391.8	23.000	2079.888		6.0000	.7238	418.4	24.000	2192.949
7.0000	.7301	431.6	23.000	1984.173		7.0000	.7435	461.2	24.000	2094.416
8.0000	.7471	469.7	23.000	1907.451		8.0000	.7603	502.3	24.000	2015.548
9.0000	.7619	506.5	23.000	1844.313		9.0000	.7749	541.9	24.000	1950.746
10.0000	.7749	542.1	23.000	1791.291		10.0000	.7877	580.4	24.000	1896.417
15.0000	.8230	708.2	23.000	1615.775		15.0000	.8348	760.1	24.000	1717.509
20.0000	.8545	861.3	23.000	1516.909		20.0000	.8653	926.4	24.000	1617.934
30.0000	.8940	1147.1	23.000	1411.760		30.0000	.9032	1238.3	24.000	1514.637

ION IS 24 CR 52

RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0680	2.2	15.711	51537.743
.0050	.0972	4.4	18.745	42839.246
.0075	.1159	6.3	20.079	36481.904
.0100	.1299	8.0	20.845	32416.462
.0200	.1666	13.2	22.222	23819.752
.0300	.1904	17.3	22.774	19747.156
.0400	.2083	20.9	23.074	17281.097
.0500	.2229	24.0	23.263	15585.935
.0600	.2354	26.9	23.393	14329.293
.0700	.2462	29.6	23.488	13349.820
.0800	.2558	32.1	23.559	12558.596
.0900	.2646	34.4	23.615	11902.094
.1000	.2726	36.6	23.661	11345.918
.1500	.3049	46.6	23.795	9453.456
.2000	.3295	55.1	23.860	8320.606
.3000	.3665	69.6	23.922	6970.175
.4000	.3945	82.2	23.950	6150.716
.5000	.4173	93.5	23.965	5592.105
.6000	.4365	103.8	23.974	5179.859
.7000	.4532	113.4	23.980	4859.412
.8000	.4680	122.5	23.984	4601.013
.9000	.4813	131.2	23.987	4386.880
1.0000	.4935	139.4	23.989	4205.639
1.5000	.5417	176.6	23.995	3590.654
2.0000	.5773	209.2	23.997	3223.234
2.5000	.6056	239.0	23.998	2972.183
3.0000	.6290	266.6	23.999	2786.772
3.5000	.6489	292.7	23.999	2642.695
4.0000	.6663	317.5	23.999	2526.643
5.0000	.6952	364.3	24.000	2349.549
6.0000	.7188	408.2	24.000	2219.353
7.0000	.7385	449.8	24.000	2118.708
8.0000	.7554	489.8	24.000	2038.107
9.0000	.7700	528.3	24.000	1971.841
10.0000	.7830	565.7	24.000	1916.247
15.0000	.8304	740.2	24.000	1732.803
20.0000	.8613	901.4	24.000	1630.218
30.0000	.8998	1203.2	24.000	1522.727

ION IS 25 MN 53

RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0688	2.2	16.215	54039.007
.0050	.0985	4.5	19.402	45071.325
.0075	.1176	6.5	20.816	38452.219
.0100	.1317	8.2	21.626	34178.194
.0200	.1691	13.6	23.090	25106.933
.0300	.1933	17.9	23.678	20816.391
.0400	.2116	21.6	23.998	18218.671
.0500	.2264	24.8	24.201	16433.226
.0600	.2390	27.8	24.340	15109.785
.0700	.2501	30.6	24.442	14078.326
.0800	.2599	33.1	24.519	13245.156
.0900	.2687	35.6	24.580	12553.883
.1000	.2768	37.9	24.629	11948.272
.1500	.3096	48.1	24.774	9975.794
.2000	.3345	56.9	24.846	8783.162
.3000	.3721	72.0	24.913	7366.797
.4000	.4005	85.1	24.943	6503.226
.5000	.4235	96.7	24.960	5914.569
.6000	.4430	107.5	24.970	5480.169
.7000	.4599	117.5	24.977	5142.518
.8000	.4749	126.9	24.982	4870.260
.9000	.4884	135.9	24.985	4644.653
1.0000	.5006	144.5	24.988	4453.711
1.5000	.5493	183.1	24.994	3805.683
2.0000	.5851	217.1	24.997	3418.738
2.5000	.6135	248.0	24.998	3154.444
3.0000	.6370	276.8	24.998	2959.323
3.5000	.6570	304.0	24.999	2807.755
4.0000	.6744	329.9	24.999	2685.715
5.0000	.7033	378.7	24.999	2499.586
6.0000	.7268	424.5	25.000	2362.861
7.0000	.7464	468.0	25.000	2257.262
8.0000	.7632	509.8	25.000	2172.773
9.0000	.7777	550.1	25.000	2103.379
10.0000	.7905	589.3	25.000	2045.225
15.0000	.8374	772.2	25.000	1853.976
20.0000	.8676	941.6	25.000	1747.855
30.0000	.9052	1259.7	25.000	1638.479

ION IS 25 MN 54

RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0680	2.2	16.116	54170.510
.0050	.0976	4.5	19.334	45379.408
.0075	.1167	6.4	20.758	38738.022
.0100	.1308	8.1	21.578	34447.127
.0200	.1681	13.4	23.059	25323.630
.0300	.1922	17.7	23.654	20997.491
.0400	.2104	21.3	23.980	18377.016
.0500	.2252	24.5	24.185	16575.588
.0600	.2377	27.5	24.327	15240.175
.0700	.2487	30.2	24.430	14199.330
.0800	.2585	32.8	24.509	13358.554
.0900	.2673	35.2	24.571	12660.956
.1000	.2754	37.4	24.620	12069.982
.1500	.3081	47.6	24.769	10059.234
.2000	.3329	56.3	24.842	8855.671
.3000	.3703	71.3	24.910	7427.384
.4000	.3986	84.1	24.942	6555.603
.5000	.4216	95.7	24.959	5961.387
.6000	.4410	106.3	24.969	5522.906
.7000	.4578	116.2	24.976	5182.093
.8000	.4728	125.6	24.981	4907.292
.9000	.4862	134.4	24.985	4679.582
1.0000	.4984	142.9	24.987	4486.863
1.5000	.5470	181.1	24.994	3832.312
2.0000	.5828	214.7	24.996	3442.238
2.5000	.6111	245.2	24.998	3175.473
3.0000	.6346	273.7	24.998	2978.516
3.5000	.6546	300.5	24.999	2825.510
4.0000	.6719	326.1	24.999	2702.301
5.0000	.7009	374.3	24.999	2514.362
6.0000	.7244	419.5	25.000	2376.276
7.0000	.7440	462.5	25.000	2269.598
8.0000	.7608	503.7	25.000	2184.222
9.0000	.7754	543.5	25.000	2114.079
10.0000	.7883	582.1	25.000	2055.278
15.0000	.8353	762.4	25.000	1861.701
20.0000	.8653	929.4	25.000	1754.030
30.0000	.9036	1242.5	25.000	1642.478

ION IS 25 MN 55

RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0673	2.1	16.018	54394.908
.0050	.0968	4.4	19.282	45680.3.
.0075	.1158	6.3	20.700	39049.25:
.0100	.1299	8.0	21.530	34712.473
.0200	.1670	13.3	23.027	25538.015
.0300	.1911	17.5	23.631	21176..64
.0400	.2092	21.1	23.961	18533.822
.0500	.2239	24.3	24.170	16716.585
.0600	.2364	27.2	24.314	15369.323
.0700	.2474	29.9	24.419	14310. 3.
.0800	.2571	32.4	24.499	13470.878
.0900	.2659	34.8	24.561	12767.019
.1000	.2740	37.0	24.612	12170. 32
.1500	.3065	47.1	24.764	10141.829
.2000	.3313	55.7	24.838	8927.496
.3000	.3685	70.5	24.908	7487.422
.4000	.3968	83.3	24.940	6607.500
.5000	.4197	94.7	24.958	6007.774
.6000	.4390	105.2	24.968	5565.248
.7000	.4559	115.0	24.976	5221.301
.8000	.4707	124.2	24.981	4943.981
.9000	.4841	133.0	24.984	4714.187
1.0000	.4963	141.4	24.987	4519.706
1.5000	.5447	179.2	24.994	3859.182
2.0000	.5804	212.3	24.996	3465.519
2.5000	.6088	242.6	24.998	3196.308
3.0000	.6322	270.7	24.998	2997.534
3.5000	.6522	297.2	24.999	2843.104
4.0000	.6695	322.5	24.999	2718.739
5.0000	.6985	370.1	24.999	2529.009
6.0000	.7220	414.7	25.000	2389.576
7.0000	.7412	457.1	25.000	2281.932
8.0000	.7585	497.8	25.000	2195.579
9.0000	.7732	537.1	25.000	2124.696
10.0000	.7860	575.2	25.000	2065.756
15.0000	.8333	753.0	25.000	1869.584
20.0000	.8639	917.6	25.000	1760.187
30.0000	.9020	1225.9	25.000	1646.504

ION IS 26 FE 54						ION IS 26 FE 56				
RANGE	BETA	ENERGY	ZEFF	DE/DX		RANGE	BETA	ENERGY	ZEFF	DE/DX
(CM)	(V/C)	(MEV/AMU)		MEV/CM		(CM)	(V/C)	(MEV/AMU)		MEV/CM
.0025	.0695	2.3	16.709	56545.066		.0025	.0680	2.2	16.507	56787.682
.0050	.0997	4.7	20.062	47328.250		.0050	.0980	4.5	19.911	47951.877
.0075	.1191	6.7	21.546	40450.511		.0075	.1173	6.5	21.426	41033.861
.0100	.1335	8.4	22.402	35966.754		.0100	.1317	8.2	22.302	36517.377
.0200	.1716	14.0	23.954	26414.710		.0200	.1695	13.7	23.888	26859.696
.0300	.1962	18.5	24.578	21903.080		.0300	.1939	18.0	24.529	22275.084
.0400	.2147	22.2	24.920	19171.747		.0400	.2123	21.7	24.881	19497.013
.0500	.2298	25.6	25.136	17294.669		.0500	.2273	25.0	25.103	17587.094
.0600	.2426	28.7	25.285	15903.430		.0600	.2400	28.0	25.257	16171.249
.0700	.2538	31.5	25.394	14819.205		.0700	.2511	30.8	25.370	15067.736
.0800	.2637	34.2	25.477	13943.463		.0800	.2610	33.4	25.456	14176.361
.0900	.2727	36.7	25.542	13216.899		.0900	.2699	35.9	25.523	13436.802
.1000	.2810	39.1	25.595	12601.414		.1000	.2781	38.2	25.577	12810.295
.1500	.3142	49.7	25.753	10507.432		.1500	.3111	48.6	25.741	10678.776
.2000	.3395	58.8	25.830	9254.130		.2000	.3362	57.6	25.821	9403.021
.3000	.3775	74.4	25.903	7761.231		.3000	.3740	72.9	25.898	7883.425
.4000	.4063	87.9	25.937	6862.613		.4000	.4026	86.1	25.933	6970.278
.5000	.4296	100.0	25.955	6243.461		.5000	.4257	97.9	25.953	6339.694
.6000	.4493	111.1	25.967	5786.578		.6000	.4453	108.8	25.964	5874.416
.7000	.4664	121.5	25.974	5431.468		.7000	.4623	119.0	25.972	5512.803
.8000	.4815	131.3	25.979	5145.147		.8000	.4774	128.5	25.978	5221.252
.9000	.4951	140.6	25.983	4907.899		.9000	.4909	137.6	25.982	4979.678
1.0000	.5075	149.5	25.986	4707.114		1.0000	.5032	146.3	25.985	4775.237
1.5000	.5565	189.6	25.993	4025.264		1.5000	.5520	185.6	25.993	4080.982
2.0000	.5926	224.8	25.996	3618.861		2.0000	.5880	220.0	25.996	3667.124
2.5000	.6211	257.0	25.997	3341.148		2.5000	.6165	251.4	25.997	3384.323
3.0000	.6447	286.9	25.998	3136.196		3.0000	.6400	280.7	25.998	3175.589
3.5000	.6647	315.2	25.999	2977.051		3.5000	.6600	308.3	25.999	3013.481
4.0000	.6821	342.2	25.999	2848.959		4.0000	.6774	334.6	25.999	2882.979
5.0000	.7110	393.0	25.999	2653.716		5.0000	.7063	384.2	25.999	2684.002
6.0000	.7344	440.8	26.000	2510.418		6.0000	.7298	430.7	25.999	2537.893
7.0000	.7539	486.2	26.000	2399.844		7.0000	.7493	475.0	26.000	2425.089
8.0000	.7706	529.8	26.000	2311.461		8.0000	.7661	517.5	26.000	2334.871
9.0000	.7850	571.9	26.000	2238.946		9.0000	.7806	558.5	26.000	2260.804
10.0000	.7977	612.8	26.000	2178.244		10.0000	.7933	598.3	26.000	2198.761
15.0000	.8439	804.2	26.000	1979.330		15.0000	.8399	784.5	26.000	1995.003
20.0000	.8736	982.0	26.000	1869.877		20.0000	.8700	957.2	26.000	1882.302
30.0000	.9102	1316.5	26.000	1759.110		30.0000	.9071	1281.5	26.000	1766.934

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| ION IS 26 FE 58 | | | | | | ION IS 27 CO 59 | | | | |
| RANGE | BETA | ENERGY | ZEFF | DE/DX | | RANGE | BETA | ENERGY | ZEFF | DE/DX |
(CM)	(V/C)	(MEV/AMU)		MEV/CM		(CM)	(V/C)	(MEV/AMU)		MEV/CM
.0025	.0666	2.1	16.310	56990.822		.0025	.0673	2.1	16.784	59426.179
.0050	.0964	4.4	19.764	48545.967		.0050	.0975	4.5	20.401	50854.020
.0075	.1156	6.3	21.309	41598.844		.0075	.1171	6.4	22.024	43655.700
.0100	.1299	8.0	22.203	37053.706		.0100	.1316	8.2	22.965	38900.277
.0200	.1675	13.3	23.824	27295.525		.0200	.1698	13.7	24.678	28650.932
.0300	.1917	17.6	24.481	22639.949		.0300	.1945	18.1	25.374	23766.722
.0400	.2100	21.2	24.842	19816.207		.0400	.2131	21.9	25.757	20804.515
.0500	.2249	24.5	25.071	17874.133		.0500	.2282	25.2	26.000	18767.415
.0600	.2375	27.4	25.229	16434.173		.0600	.2410	28.3	26.169	17257.128
.0700	.2486	30.2	25.345	15311.743		.0700	.2522	31.1	26.293	16079.962
.0800	.2584	32.7	25.434	14405.030		.0800	.2622	33.7	26.388	15129.085
.0900	.2672	35.1	25.504	13652.717		.0900	.2711	36.2	26.462	14340.164
.1000	.2754	37.4	25.560	13015.392		.1000	.2794	38.6	26.523	13671.850
.1500	.3082	47.6	25.729	10847.019		.1500	.3126	49.1	26.705	11398.198
.2000	.3331	56.4	25.813	9549.213		.2000	.3379	58.2	26.795	10037.480
.3000	.3706	71.4	25.893	8003.399		.3000	.3759	73.7	26.882	8416.803
.4000	.3990	84.3	25.929	7076.056		.4000	.4046	87.1	26.922	7448.927
.5000	.4220	96.0	25.950	6434.230		.5000	.4279	99.1	26.944	6775.451
.6000	.4415	106.6	25.962	5960.699		.6000	.4476	110.1	26.958	6278.586
.7000	.4584	116.6	25.971	5592.694		.7000	.4647	120.4	26.967	5892.462
.8000	.4734	125.9	25.977	5296.003		.8000	.4798	130.2	26.974	5581.177
.9000	.4868	134.9	25.981	5050.178		.9000	.4934	139.4	26.978	5323.272
1.0000	.4991	143.4	25.984	4842.144		1.0000	.5058	148.2	26.982	5105.025
1.5000	.5477	181.8	25.992	4135.705		1.5000	.5548	188.0	26.991	4364.008
2.0000	.5836	215.5	25.995	3714.530		2.0000	.5909	223.0	26.995	3921.765
2.5000	.6120	246.2	25.997	3426.735		2.5000	.6194	254.9	26.996	3620.441
3.0000	.6354	274.8	25.998	3214.291		3.0000	.6429	284.6	26.997	3397.794
3.5000	.6554	301.7	25.998	3049.277		3.5000	.6630	312.6	26.998	3224.918
4.0000	.6728	327.4	25.999	2916.415		4.0000	.6803	339.3	26.999	3085.778
5.0000	.7018	375.9	25.999	2713.779		5.0000	.7093	389.7	26.999	2873.687
6.0000	.7253	421.3	25.999	2564.919		6.0000	.7327	437.1	26.999	2718.010
7.0000	.7449	464.5	26.000	2449.936		7.0000	.7522	482.1	26.999	2597.867
8.0000	.7612	505.9	26.000	2357.926		8.0000	.7689	525.3	27.000	2501.818
9.0000	.7763	545.9	26.000	2282.344		9.0000	.7834	567.0	27.000	2422.998
10.0000	.7891	584.7	26.000	2218.992		10.0000	.7961	607.5	27.000	2357.003
15.0000	.8361	766.0	26.000	2010.522		15.0000	.8424	797.0	27.000	2140.580
20.0000	.8665	933.9	26.000	1894.676		20.0000	.8723	972.9	27.000	2021.271
30.0000	.9042	1248.3	26.000	1774.886		30.0000	.9091	1303.8	27.000	1900.019

ION IS 28 NI 58

RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0693	2.2	17.457	61782.747
.0050	.1003	4.7	21.188	52563.813
.0075	.1202	6.8	22.859	45142.948
.0100	.1350	8.6	23.827	40204.649
.0200	.1742	14.5	25.598	29563.315
.0300	.1994	19.1	26.316	24522.863
.0400	.2183	23.0	26.711	21468.890
.0500	.2338	26.5	26.963	19369.668
.0600	.2468	29.7	27.137	17813.738
.0700	.2583	32.7	27.266	16601.196
.0800	.2684	35.5	27.364	15621.854
.0900	.2776	38.1	27.441	14809.376
.1000	.2860	40.6	27.503	14121.145
.1500	.3199	51.6	27.692	11779.922
.2000	.3456	61.2	27.786	10378.847
.3000	.3843	77.5	27.876	8710.130
.4000	.4136	91.6	27.918	7716.102
.5000	.4373	104.2	27.941	7022.500
.6000	.4573	115.9	27.956	6510.762
.7000	.4746	126.8	27.965	6113.075
.8000	.4900	137.0	27.972	5792.468
.9000	.5038	146.8	27.977	5526.845
1.0000	.5163	156.1	27.981	5302.074
1.5000	.5658	198.2	27.990	4539.004
2.0000	.6022	235.2	27.994	4083.752
2.5000	.6309	269.0	27.996	3773.566
3.0000	.6545	300.5	27.997	3544.567
3.5000	.6746	330.3	27.998	3366.856
4.0000	.6920	358.6	27.998	3223.907
5.0000	.7208	412.2	27.999	3006.210
6.0000	.7441	462.6	27.999	2846.634
7.0000	.7635	510.6	27.999	2723.664
8.0000	.7800	556.7	28.000	2625.513
9.0000	.7942	601.3	28.000	2545.107
10.0000	.8067	644.5	28.000	2477.909
15.0000	.8520	847.6	28.000	2258.852
20.0000	.8810	1036.8	28.000	2139.799
30.0000	.9163	1394.1	28.000	2022.652

ION IS 28 NI 60

RANGE (CM)	BETA (V/C)	ENERGY (MEV/AMU)	ZEFF	DE/DX MEV/CM
.0025	.0679	2.2	17.249	61960.413
.0050	.0986	4.6	21.031	53181.459
.0075	.1185	6.6	22.733	45738.226
.0100	.1333	8.4	23.722	40771.984
.0200	.1722	14.1	25.528	30026.080
.0300	.1972	18.7	26.263	24910.293
.0400	.2161	22.5	26.669	21809.764
.0500	.2314	26.0	26.922	19674.351
.0600	.2444	29.1	27.102	18092.782
.0700	.2552	32.0	27.239	16860.134
.0800	.2658	34.7	27.340	15864.492
.0900	.2749	37.3	27.420	15038.465
.1000	.2833	39.8	27.484	14338.741
.1500	.3170	50.6	27.679	11958.384
.2000	.3425	60.0	27.776	10533.905
.3000	.3810	76.0	27.870	8837.369
.4000	.4101	89.8	27.914	7828.475
.5000	.4336	102.2	27.938	7122.925
.6000	.4535	113.6	27.953	6602.412
.7000	.4708	124.3	27.963	6197.929
.8000	.4861	134.3	27.970	5871.855
.9000	.4998	143.9	27.976	5601.710
1.0000	.5122	153.0	27.980	5373.117
1.5000	.5616	194.2	27.990	4597.029
2.0000	.5979	230.5	27.994	4134.065
2.5000	.6265	263.5	27.996	3818.523
3.0000	.6501	294.3	27.997	3585.561
3.5000	.6702	323.4	27.998	3404.744
4.0000	.6876	351.2	27.998	3259.268
5.0000	.7164	403.6	27.999	3037.651
6.0000	.7393	452.8	27.999	2875.120
7.0000	.7592	499.6	27.999	2749.803
8.0000	.7758	544.6	28.000	2649.717
9.0000	.7901	588.0	28.000	2562.671
10.0000	.8027	630.2	28.000	2199.053
15.0000	.8484	828.1	28.000	2274.839
20.0000	.8777	1012.1	28.000	2152.291
30.0000	.9136	1359.1	28.000	2030.115

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        ION IS   30 ZN 64
RANGE     BETA    ENERGY    ZEFF    DE/DX
(CM)     (V/C)   (MEV/AMU)           MEV/CM
 .0025   .0677       2.1   17.944 67029.630
 .0050   .0991       4.6   22.105 58513.911
 .0075   .1195       6.7   24.001 50582.310
 .0100   .1347       8.6   25.107 45171.237
 .0200   .1746      14.5   27.142 33314.502
 .0300   .2002      19.2   27.976 27649.486
 .0400   .2195      23.3   28.439 24210.575
 .0500   .2352      26.9   28.736 21845.250
 .0600   .2484      30.1   28.942 20091.655
 .0700   .2600      33.2   29.095 18724.944
 .0800   .2703      36.0   29.212 17621.053
 .0900   .2796      38.7   29.305 16705.253
 .1000   .2881      41.2   29.380 15929.517
 .1500   .3225      52.5   29.610 13290.845
 .2000   .3485      62.3   29.725 11712.007
 .3000   .3876      79.0   29.838  9831.864
 .4000   .4171      93.4   29.891  8706.172
 .5000   .4410     106.3   29.921  7940.929
 .6000   .4612     118.3   29.940  7363.062
 .7000   .4787     129.4   29.952  6914.063
 .8000   .4942     139.9   29.961  6552.149
 .9000   .5081     149.9   29.968  6252.345
1.0000   .5207     159.5   29.973  5998.683
1.5000   .5706     202.7   29.986  5137.793
2.0000   .6071     240.6   29.992  4624.419
2.5000   .6359     275.3   29.994  4274.243
3.0000   .6596     307.7   29.996  4016.399
3.5000   .6796     338.2   29.997  3816.225
4.0000   .6970     367.4   29.997  3655.273
5.0000   .7258     422.5   29.998  3410.302
6.0000   .7490     474.3   29.999  3230.875
7.0000   .7683     523.7   29.999  3092.720
8.0000   .7847     571.1   29.999  2982.541
9.0000   .7989     617.0   29.999  2892.363
10.0000  .8113     661.6   29.999  2817.070
15.0000  .8562     871.0   30.000  2572.360
20.0000  .8847    1066.3   30.000  2440.327
30.0000  .9194    1436.1   30.000  2312.590
```

Appendix II

In Table II are listed some quantities which are useful for calculations on relativistic ions. The first column in the table lists the kinetic energy per nucleon. The energy is linked to other parameters by common relativistic dynamics.

Momentum:

Starting from relativistic invariant

$$E^2 = p^2c^2 + m_o^2c^4 \qquad \ldots \ldots \qquad A2\text{-}1$$

the momentum p(MeV/c) of a proton with mass m_p (MeV) is given by

$$p = \frac{1}{c} (E^2 - m_p^2c^4)^{1/2} \qquad \ldots \ldots \qquad A2\text{-}2$$

or $\quad pc = (E^2 - m_p^2c^4)^{1/2} \qquad \ldots \ldots \qquad A2\text{-}3$

Rigidity:

The rigidity $p(a,z)$ of a heavy ion with mass number A and charge z is given by

$$p(A,z) = \frac{A}{z} pc \qquad \qquad A2\text{-}4$$

The momentum times c can be found in column four.
A and z for a certain ion can be found in the track parameter table.

PRINTOUT TABLE II

Velocity (β), Momentum times Velocity (pc, MeV) as a
function of Heavy Ion Energy (E, MeV/amu)

ENERGY MEV/AMU	BETA (V/C)	GAMMA	PC (MEV)
5.	.1032	1.01	96.6
10.	.1454	1.01	136.8
20.	.2040	1.02	194.0
30.	.2479	1.03	238.3
40.	.2840	1.04	275.8
50.	.3152	1.05	309.2
60.	.3426	1.06	339.6
70.	.3674	1.08	367.8
80.	.3898	1.09	394.2
90.	.4105	1.10	419.2
100.	.4296	1.11	443.0
200.	.5678	1.21	642.2
300.	.6542	1.32	805.4
400.	.7146	1.43	951.3
500.	.7594	1.54	1086.8
600.	.7938	1.64	1215.5
700.	.8211	1.75	1339.3
800.	.8430	1.86	1459.4
900.	.8611	1.97	1576.7
1000.	.8761	2.07	1691.8
1100.	.8887	2.18	1805.1
1200.	.8995	2.29	1917.0
1300.	.9088	2.40	2027.6
1400.	.9168	2.50	2137.1
1500.	.9237	2.61	2245.8
1600.	.9279	2.72	2353.6
1700.	.9353	2.83	2460.9
1800.	.9401	2.93	2567.5
1900.	.9444	3.04	2673.6
2000.	.9482	3.15	2779.3
2500.	.9625	3.68	3302.4
3000.	.9715	4.22	3819.3
3500.	.9777	4.76	4332.2
4000.	.9820	5.30	4842.4
4500.	.9852	5.83	5350.7
5000.	.9876	6.37	5857.6
6000.	.9909	7.44	6868.3
7000.	.9931	8.52	7876.3
8000.	.9946	9.59	8882.5
9000.	.9956	10.67	9887.4
10000.	.9964	11.74	10891.4

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